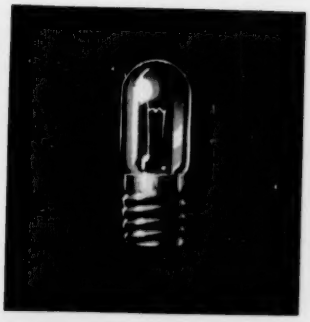
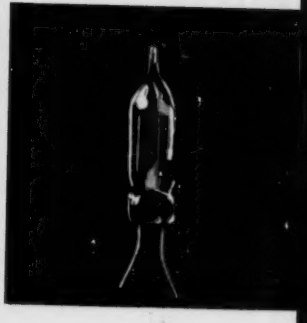
AUGUST 6, 1959

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY





Miniature Lamps

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FARNSWORTH

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The same courteous prompt service by bearing experts go into every order at Bound Brook's newly expanded production facilities. There is no penalty for small orders — regardless of quantity.

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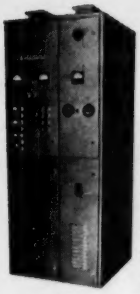

HURLETRON DC PRINTING PRESS DRIVE. "Years of experience with Bodine Motors in critical applications . . . plus the service of the Bodine Organization, gives us assurance of satisfactory performance." —Electric Eye Equipment Company.

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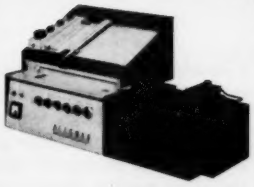
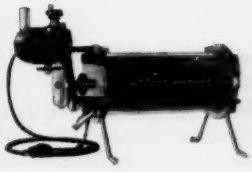
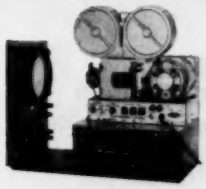


BECKMAN ANALYTICAL INSTRUMENTS. "Bodine Motors are used in several of our precision instruments where critical specifications must be met and maintained. Twenty-four hour operation of our products is commonplace."—Beckman Scientific and Process Instruments Division.



KAY-CROSS OXYGENATOR. "The oxygenator must be of the utmost reliability since it takes the place of the lungs during critical surgery. We chose a Bodine Motor because of the high quality standards required. They have satisfied our needs very nicely." — Pemco, Inc.



GRASS OSCILLOSCOPE RECORDING CAMERA. "The Bodine Motor you designed for us far exceeds the performance of a competitive motor. We have used Bodine Motors for 24 years . . . and many motor application problems have been solved with the aid of your engineers."—Grass Instrument Co.

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When you're developing a new or improved product, consult a Bodine motor application engineer. One of Bodine's 3500 standard motors is almost certain to suit your exact needs. And 300 different types and sizes are carried in stock . . . ready for immediate shipment. Request Bulletin S-1 or see our catalog in Sweet's Product Design File.

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Other applications for Bodine Motors: vending machines, communication equipment, sound recorders, automatic scales, respirators, voltage regulators, X-ray timers, traffic signal timers, stirrers, sanders, letter openers, envelope sealers . . . plus many, many other applications.

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2508 West Bradley Place, Chicago 18, Illinois

. . . the power behind the leading products

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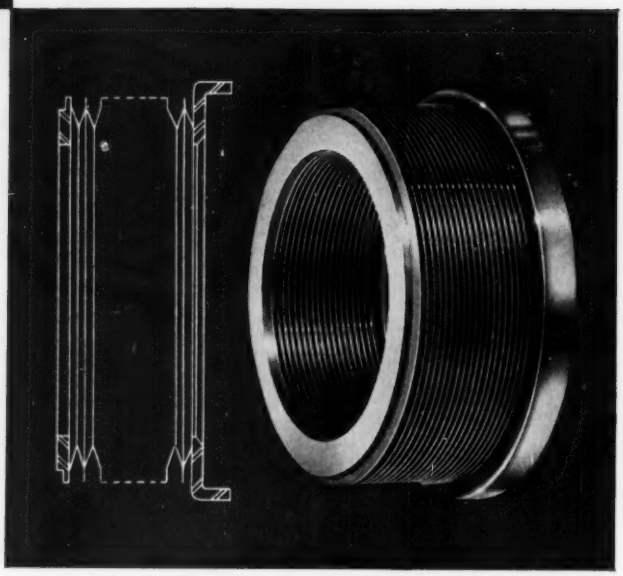
C/R DESIGN NOTES

How C/R's New Metal Bellows Seal Meets Seemingly Impossible Operating Conditions



Operating Ranges

Temperature	−400° to 1000° F.
Pressure	500 psi
R.P.M.	80,000 plus

These known operating ranges indicate the function of this seal. It is designed for applications where temperatures and mediums to be sealed forbid the use of any organic materials. Typically, these applications include fuel pumps, compressor power units and turbine starters characteristic in rockets and missiles. Other applications include mechanisms which are exposed to a high level of radioactivity.

Design Advantages

The C/R metal bellows seal consists of a metal bellows — a welded homogeneous unit which is secured at one end — and a carrier ring in which the sealing face is mounted. The seal does not contact the shaft. It is stationary, and the only rubbing surfaces are the sealing face and mating ring. These surfaces are precision lapped to provide a positive seal with minimum friction. At any given pressure, the seal can be designed to maintain proper and constantly effective face loads. It orients immediately to run-out and will resist any torques it is subjected to in operation. The design has high end-play tolerance: Chicago Rawhide engineers have deflected a bellows .100 in. for three million cycles at 1750 cpm and at a temperature of 500° F. with no adverse effects.

A further advantage is relatively light weight and compactness. The C/R metal bellows seal can be designed for minimum axial and radial space. Axially, complete seals can be produced within a ¼ in. cross-section. Radially, dimensions are comparable with conventional end face seals.

The C/R metal bellows seal can also be designed with an extremely low coefficient of expansion. The importance of this factor becomes apparent with the fact that in many applications the operating temperature may change hundreds of degrees in a very few seconds.

Mediums To Be Sealed

Virtually any known liquid or gas may be positively sealed with this design, depending upon duration or service life. From a practical viewpoint, the C/R metal bellows seal is the best design for the sealing of cryogenic and high-energy fuels such as LOX, hydrogen peroxide, fluorine and other missile and rocket propellants.

Where possible, lubrication of the two sealing faces is desirable to prolong service life. However, the medium being sealed commonly acts as the lubricant and may be merely hot gas.

Materials

Sealing faces and mating rings for the C/R metal bellows seal are available in a variety of materials including carbons, carbides, ceramics and various alloyed metals for both high temperature and corrosion resistance. The bellows can be furnished in any of several metals and alloys such as stainless steel, Monel, Inconel X, Ni-Span C and other special alloy steels.

Consult C/R Engineers

Each application for the C/R metal bellows seal is essentially a custom-design and an intimate knowledge of all conditions to be encountered must be known by Chicago Rawhide engineers to produce the correct combination of properties in the seal. Then, whether you require five, fifty or five thousand seals, Chicago Rawhide will design and produce the correct seal to solve your problem.

Helpful Design Data:

We will gladly furnish you with a design guide and space envelope data concerning the C/R Metal Bellows Seal. Just write for Bulletin MBS-1 on your company letterhead.

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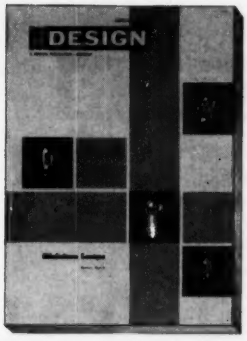

Front Cover: Lighting up this issue's front cover are four miniature lamps, used by artist George Farnsworth to indicate the many types available. J. D. Lash and J. W. Tuttle, in their article on Page 116, discuss the factors to consider in selecting a "tiny light."

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COLIN CARMICHAEL—*Editorial*

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Starting salaries of new graduates top last year's—tunnel diode shows promise in semiconductor family—design of nuclear merchant ship stresses safety—new process makes rubber suitable for subminiature electronic parts—metal tubing assumes ribbon form for shipping, inflates for use—aluminized solid-fuel propellant boosts missile velocities up to 30 per cent—thermoelectric air conditioners are being developed for subs—Ohio State redesigns engineering cirricula.

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Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals

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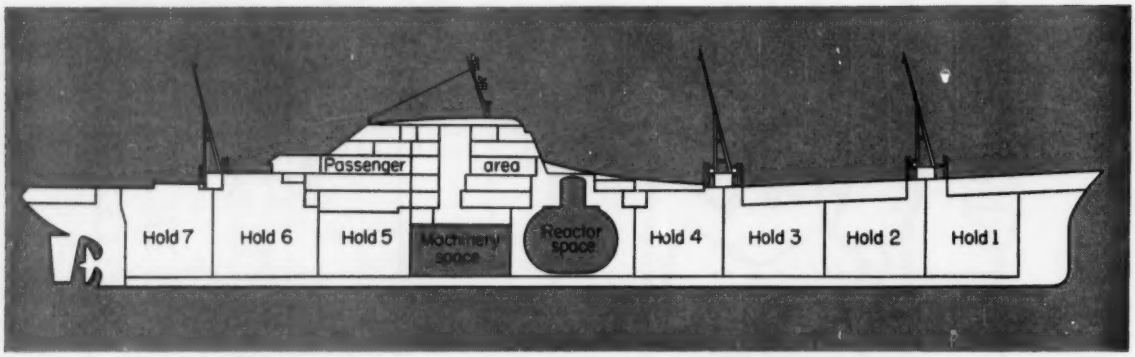
Well-Padded Reactor Powers N.S. Savannah



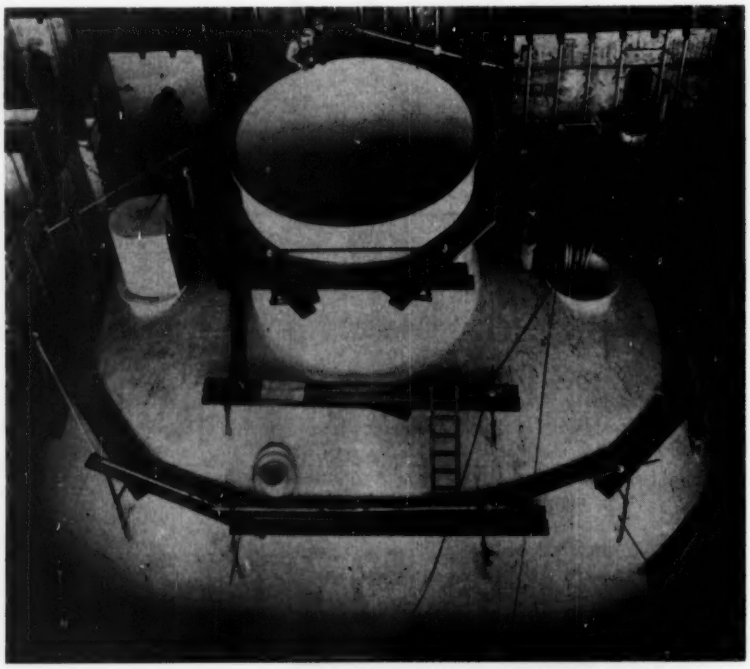
Structurally, Savannah differs little from ordinary passenger-cargo vessels. Her designers point to only one significant difference—the heavy foundation under the reactor plant, which serves as protection in case of grounding. Not shown in the drawing are anti-roll stabilizers, mounted on the hull amidships. Operated hydraulically by a "sea-sensing" gyro system, each fin has a lift of 70 tons at a speed of 20 knots. Savannah is designed to stay afloat, even though two of her main compartments become totally flooded.

Nuclear Ship's Heart Safe From Any Marine Mishap

CAMDEN, N. J.—In the words of her designers, "N.S. Savannah has been provided with an almost unprecedented degree of operational safety." The sleek passenger-cargo liner, launched late last month by New York Shipbuilding Corp., had to be designed with the worst in mind. Besides the familiar safeguards necessary in landlocked nuclear powerplants, Savannah inherits obvious occupational hazards. Savannah's nuclear powerplant is designed to be practically impervious to collision, sinking, grounding, or any other calamities that can beset a ship.

First line of defense for the reactor is a steel containment vessel 35 ft in diameter and 50.5 ft long which houses the entire nuclear plant. This shell also serves two other purposes: It must withstand the pressure surge from the "maximum credible accident," which the builders define as the rupture of a main coolant pipe; it must support 500 tons of radiation shielding.

Protection of the containment complex is the next line of resistance. Since no criteria were available, Savannah's designers made an elaborate review of ship accidents. They developed methods of predicting structural damage to vessels struck in collisions as a function of



Steel shell for the reactor plant and primary cooling system is designed to contain all the water and steam released in event of mechanical failure of the reactor's pressurized water loops (maximum credible accident). The containment vessel is surrounded by 500 tons of lead and polyethylene radiation shielding and rests on a slab of reinforced concrete 4 ft thick.

New Repeat Accuracy . . . the Cutler-Hammer 10316 Precision Limit Switch always trips at the same point of "in" and "out" plunger travel.
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OUT
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A
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MUST BE SAME POLARITY

NEW HIGH PRECISION in a NEW PRECISION LIMIT SWITCH

- **LASTS 10 TIMES LONGER**
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The new 10316 will change your ideas about what an industrial duty precision limit switch can do.

Comparative tests proved the 10316 provides ten times greater life. It could not be teased. And it always fired at exactly the same points of "in" and "out" plunger travel. Prove it yourself! You'll discover a *new high* in electrical and mechanical life, the sureness of repeat action, the utter dependability of the Cutler-Hammer 10316 Precision Limit Switch.

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If you use precision limit switches at all, the 10316 is for you. Know the difference—write for fully explanatory Pub. EA 154-Q243. Cutler-Hammer Inc., Milwaukee 1, Wisconsin.

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Giant Xenon Lamp Lights Entire Auditorium

Two million lumen xenon lamp, developed by Osram GmbH, Germany, was recently used as a single light source to illuminate a 92,000 sq ft sports arena and auditorium (right). Nearly 8 ft long, the lamp consists essentially of a quartz tube only 2 in. in diam. Rated at 65 kw and operating at a gas pressure of 14.2 psi, it delivers a luminous flux equivalent to that emitted by 4650 conventional 40-w bulbs. Current consumption is 250 amp. Unlike previous xenon lamps, it does not rely on artificial cooling. Light given off contains all the spectral colors and strongly resembles natural sunlight. Fifty of the giants are reported capable of lighting all of West Berlin, provided they are suspended high enough above the city.

speed and displacement of the vessels involved. On the basis of data gleaned in these studies, the nuclear liner is designed to withstand, without damage to her reactor compartment, a collision with all but one per cent of the world's merchant fleet. These odds are considered safe.

In event of a collision broadside to the reactor compartment, here is what the ramming ship would be up against (from the outside in): A layer of extra heavy steel plate; 17 ft of stiffened ship structure; a heavy longitudinal collision bulkhead; 2 ft of collision mat (alternate layers of 1-in. steel plate and 3-in. redwood planks); the reactor containment vessel.

In case of grounding, which is similar to collision in its effects, except that damage is ordinarily more localized, the reactor is equally well protected. The inner bottom, below the reactor space, is "egg-crated" with transverse floors at every frame. Mounted on this, in a cradle of reinforced concrete 4 ft thick, is the reactor containment vessel.

If Savannah should sink, the containment shell will automatically flood to prevent its collapse in deep water. Flooding valves are designed to close when pressure equalizes, so that containment integrity will be maintained even after sinking. Salvage connections have been installed to allow containment purging or filling with concrete in case of sinking in shallow water where recovery or immobilization of the reactor plant seem advisable.

According to schedule, Savannah will go critical in the late spring of 1960. During the following summer she will go to sea for trials.

Topics

Keeping a cool head can be as easy as putting on your hat, if you're in the right line of work. Farmers and operators of construction equipment may benefit from an air-conditioned helmet consisting of a lightweight glass fiber headpiece connected to a hermetically sealed, battery-operated cooler. Price of this refreshing fedora is a cool $325, plus installation. Based on work done by physiologists at Litton Industries' space laboratory, the helmet will be marketed by Jamieson Laboratories Inc., Santa Monica, Calif.

• • •

A mechanical nose that knows more than a human's can distinguish between natural and artificial flavors, cigar and cigarette smoke, and different types of whiskey on the breath. The super sniffer, developed by Evans Research, New York, contains a series of ionization detectors combined with gas chromatographs. It inhales vapor surrounding an aromatic material and separates the components; an ionization detector notes the presence of each material. The sniffer is expected to find use in odor-flavor research, quality control, and in research for plastics, paper, medicine, and pharmaceuticals.

• • •

TV drama starring a live reactor is featured, via closed circuit, on a 6 by 8-ft screen in the lounge of the *N. S. Savannah.* Two cameras will pan the reactor compartment to provide a complete view of the reactor at work; cables leading to the cameras have special po'ing to eliminate danger of radioactive leakage. Sound of the reactor's "heart" will be relayed over an audio hookup, and the television system will also carry motion picture films and other filmed entertainment on the big screen in the passenger lounge and in other areas of the ship.

Something New's Been Added

Beginning with this issue, MACHINE DESIGN expands its editorial content with a new department called *Backtalk*—in the back of the magazine. This page gives the editors an opportunity to stop talking engineering and hold forth on three other favorite subjects: Our readers, our magazine, and ourselves. It will also provide a place for discussion of off-beat subjects which are of interest to engineers. *Backtalk* makes its debut on Page 212.

Now you can *speed-test* gears up to 4000 RPM

Since the accuracy of any gear test depends on how well it simulates actual operating conditions, we've developed a hypoid tester with speeds up to 4000 RPM. The higher range of speed on the No. 17A-4000 Hypoid Tester makes possible a new standard in the testing of bevel gears.

Complete testing on one machine. The No. 17A-4000 Hypoid Tester is arranged for both power and slow rolling tests. With the power test you can observe a gear's smoothness of operation, its noise characteristics, and its tooth contact pattern.

Roll test the gear and you get accurate readings of its eccentricity, tooth size, spacing, and profile.

With the No. 17A-4000 Tester you can test any right angle straight bevel, Zerol® bevel, spiral bevel and hypoid gear of any pitch and up to 20″ OD.

Pre-set backlash control. The No. 17A-4000 Tester has a new hydraulic backlash control mechanism. The control automatically duplicates your pre-set backlash value when you change the relative positions of a gear pair to simulate actual operation.

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New bulletin. We've prepared a bulletin on the No. 17A-4000 Hypoid Tester to answer any questions you might have about its construction or operation. Write for a copy.

GLEASON WORKS

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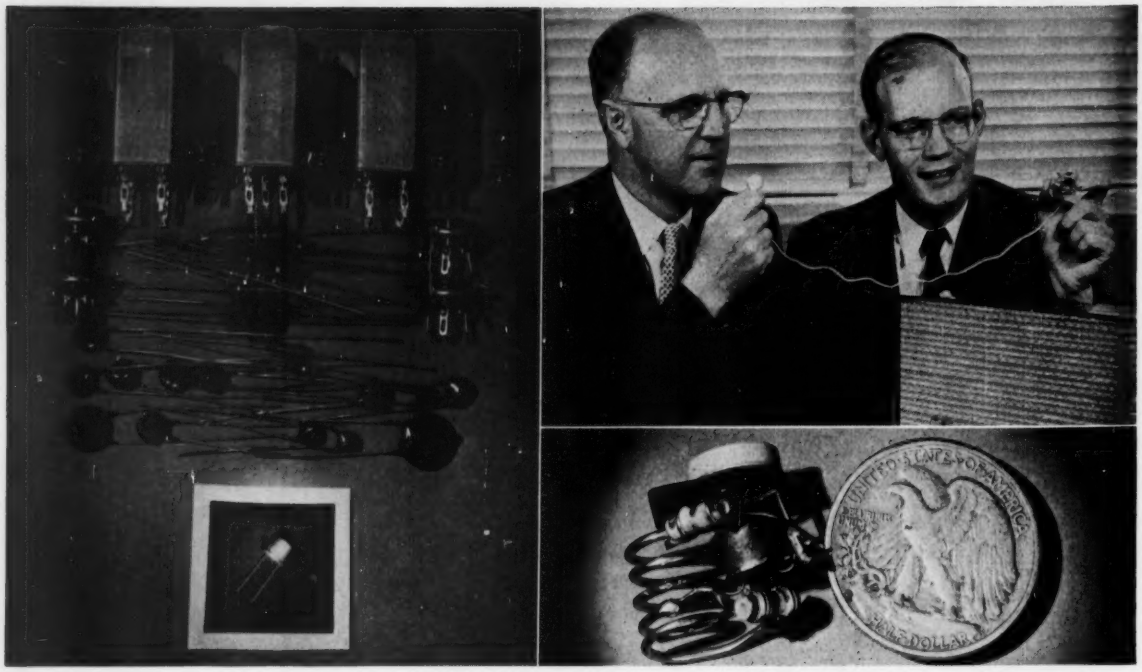

Tunnel diode (inset photo, left) simultaneously performs all amplification, oscillation, conversion, limiting, detection, and automatic frequency control functions for an FM receiver. Rebuilt with the new active component, an FM receiver circuit would not need any of the conventional components shown. Photos above show a complete tunnel-diode transmitter with a half-mile range. No larger than a 50-cent piece, the transmitter is built with one variable and two fixed capacitors, tuning coil, and the tunnel diode.

Pace Steps Up for Tunnel Diodes

GE Unravels Action, Sees Early Application

NEW YORK—Industry has an up-to-date report on first-year accomplishments of a precocious new member of the semiconductor family. According to General Electric's director of research, Dr. Guy Suits, the "tunnel diode"—first reported in 1958 by Japanese scientist Leo Esaki — is now better understood and closer to commercial application. Limited numbers of experimental samples will be available to electronic-circuit designers within the next few months, says Dr. Suits.

First cousin to the transistor—but with major differences in the mechanics of electric-charge transfer—the tunnel diode has a future that "depends only on the ingenuity of circuit designers to utilize its unique characteristics." Properties from the electronic-circuit point of view are impressive:

- Extreme speed—on-off switching times are better than a millimicrosecond.
- Stable characteristics insensitive to temperature change—a sample has operated in temperatures from 600 F to near absolute zero.
- Modest power-supply requirements—minimum value (10^{-6} watts) promises to reduce component-cooling problems.
- Low noise level—only bulky masers and parametric amplifiers compete.
- Simplicity, light weight, reduced semiconductor quality-control requirements.

The tunnel diode takes its name from the phenomenon that makes it possible — quantum-mechanical tunneling. "Tunneling" is an oversimplified but convenient picture for visualizing the mechanism by which an electron disappears from one side of a potential barrier, appears instantaneously on the other side although it apparently has insufficient energy to make the jump. Charges move at the speed of light.

The classical picture for the transistor, on the other hand, has an electron starting from an emitter and diffusing at relatively slow speed across the base region to a collector. Time for movement of the charge carrier therefore sets a fundamental limit to the speed (and frequency capabilities) of the transistor. In contrast, the tunnel diode—when used as an on-off switch—operates in a fraction of a millimicrosecond (less than one billionth of a second).

High-speed action, combined with a unique "negative resistance" operating characteristic, suits the tunnel diode for use in a wide variety of amplifier, oscillator, and computer circuits. GE sees it superior to tubes and transistors in low-noise amplifiers and high-frequency mixers.

According to GE developers, the first break in their attempts to unravel and interpret tunnel-diode behavior came when experiments were conducted with the unit immersed in liquid helium. Pronounced differences between current-voltage characteristics at this temperature and those at high temperatures were observed. GE tracked down the effects ("wiggles" in the performance curves) to the generation of a little sound wave, or *phonon*, each time an electron tunneled in the diode. The new knowledge is likely to have repercussions in many areas of solid-state physics and will undoubtedly lead to improvements in other semiconductor devices.

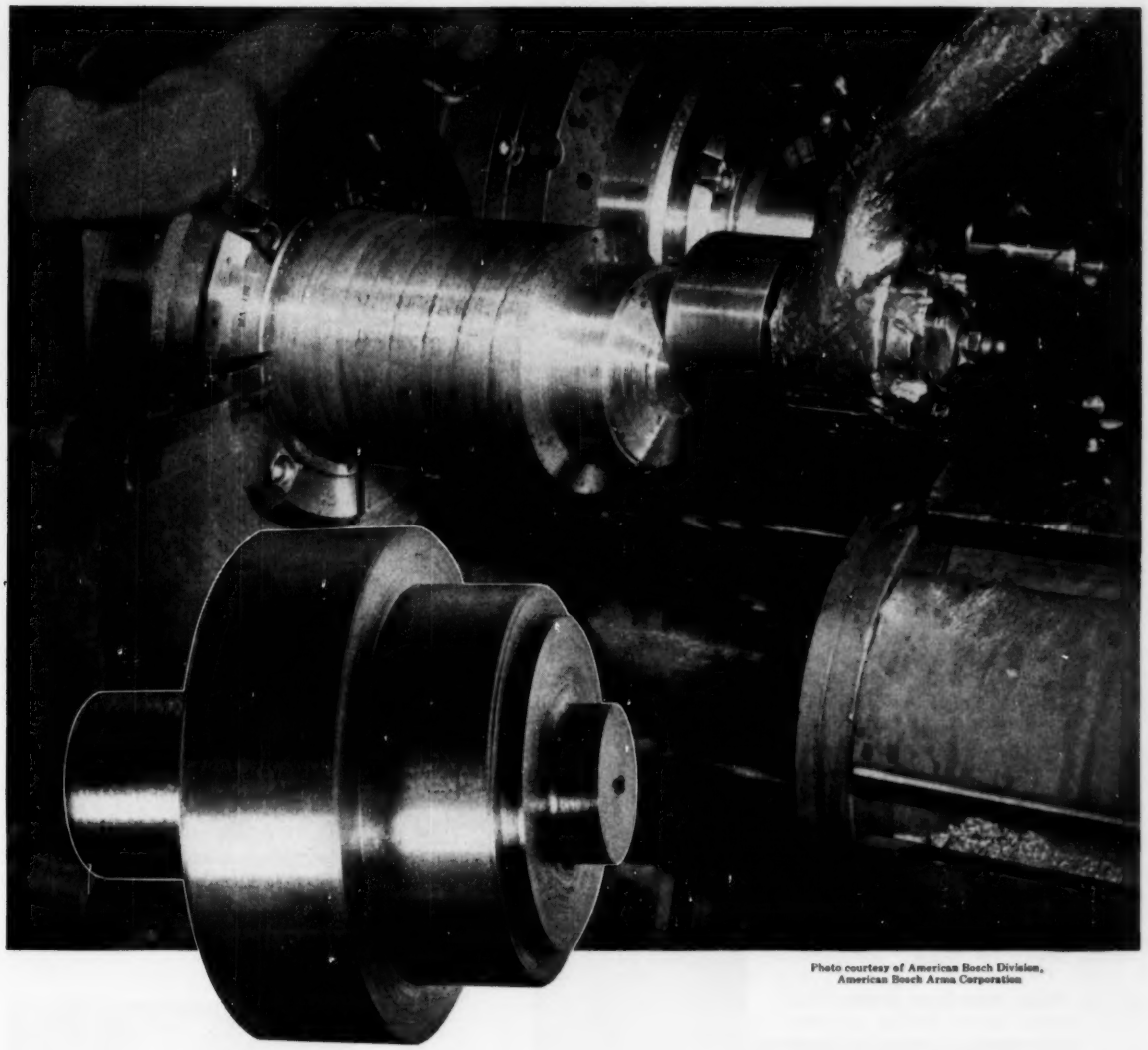

Photo courtesy of American Bosch Division, American Bosch Arma Corporation

Leaded Nitralloy Takes a Big Bite Out of Machining Time!

By switching to Nitralloy Leaded for this hydraulic head, secondary lathe operations and expensive heat treatment were completely eliminated. Produced in a single machining operation, the part is now sent directly to the grinding department. Spindle speeds and feeds were also increased.

For complete information about other fast-machining Aristoloy leaded steels or standard carbon, alloy and stainless grades, call the Copperweld representative in your nearest large city. Or write for booklet entitled, "A Complete Line of Leaded Steels," and NEW PRODUCTS & FACILITIES CATALOG.

ARISTOLOY STEELS

COPPERWELD STEEL COMPANY

ARISTOLOY STEEL DIVISION • 4017 Mahoning Ave., Warren, Ohio • EXPORT: Copperweld Steel International Co., 225 Broadway, New York 7, N. Y.

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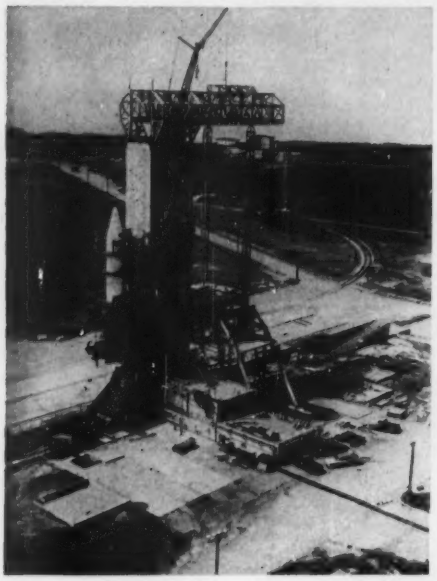
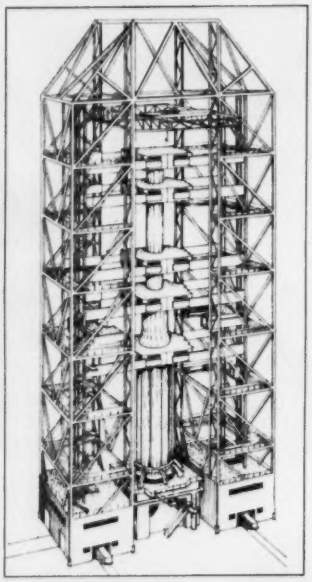
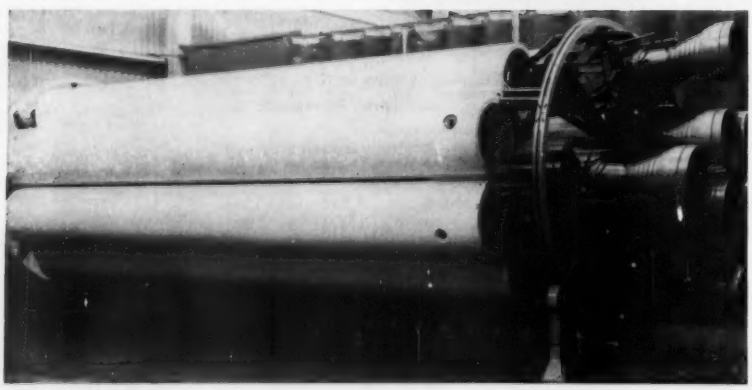
Progress Report: Saturn on Schedule





Project Saturn, ARPA's vehicle designed to orbit a multi-ton communications satellite 22,000 miles up, will start static firings late this year. Test and service towers will be ready. Army's rocket-engine static test tower (above left) is being modified to handle the 1.5 million lb thrust Saturn booster. Steel pilings 60 ft deep are being added for structural support, and other improvements are also under way. A giant self-propelled tower in the planning stage (above right) will erect and service Saturn for flight.

Missile stages have been chosen. First stage (model below) will be a cluster of eight liquid-propellant engines built from existing Jupiter and Thor components. Second stage will be modified Titan ICBM first stage, and third stage will be the new Centaur rocket currently under development. Saturn will stand 200 ft tall, weigh about 580 tons at blastoff, carry 500 tons of fuel and oxidizer. Model of Saturn shows size contrast with Jupiter, right.



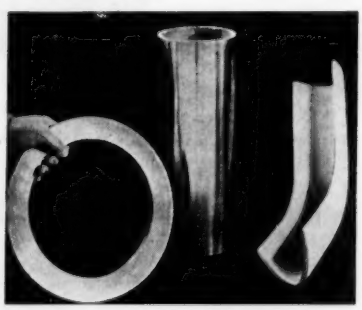
New Plastic Glue Mends Broken Bones

WASHINGTON — A plastic glue designed to repair damaged bones is being tested by the Walter Reed Army Institute of Research. The glue will reportedly put a fracture-suffering patient back on his feet in 48 hr.

The plastic, a polyurethane polymer, is a foam that solidifies into a porous, rigid substance when applied to a fracture. It bonds the bones together until bone cells grow through the material. Over a period of several months the body completely replaces the plastic with natural bone. In addition to "gluing" broken bones, the substance can be used to replace fragments of damaged bone. In this case it would be molded by the surgeon to match the original bone contours.

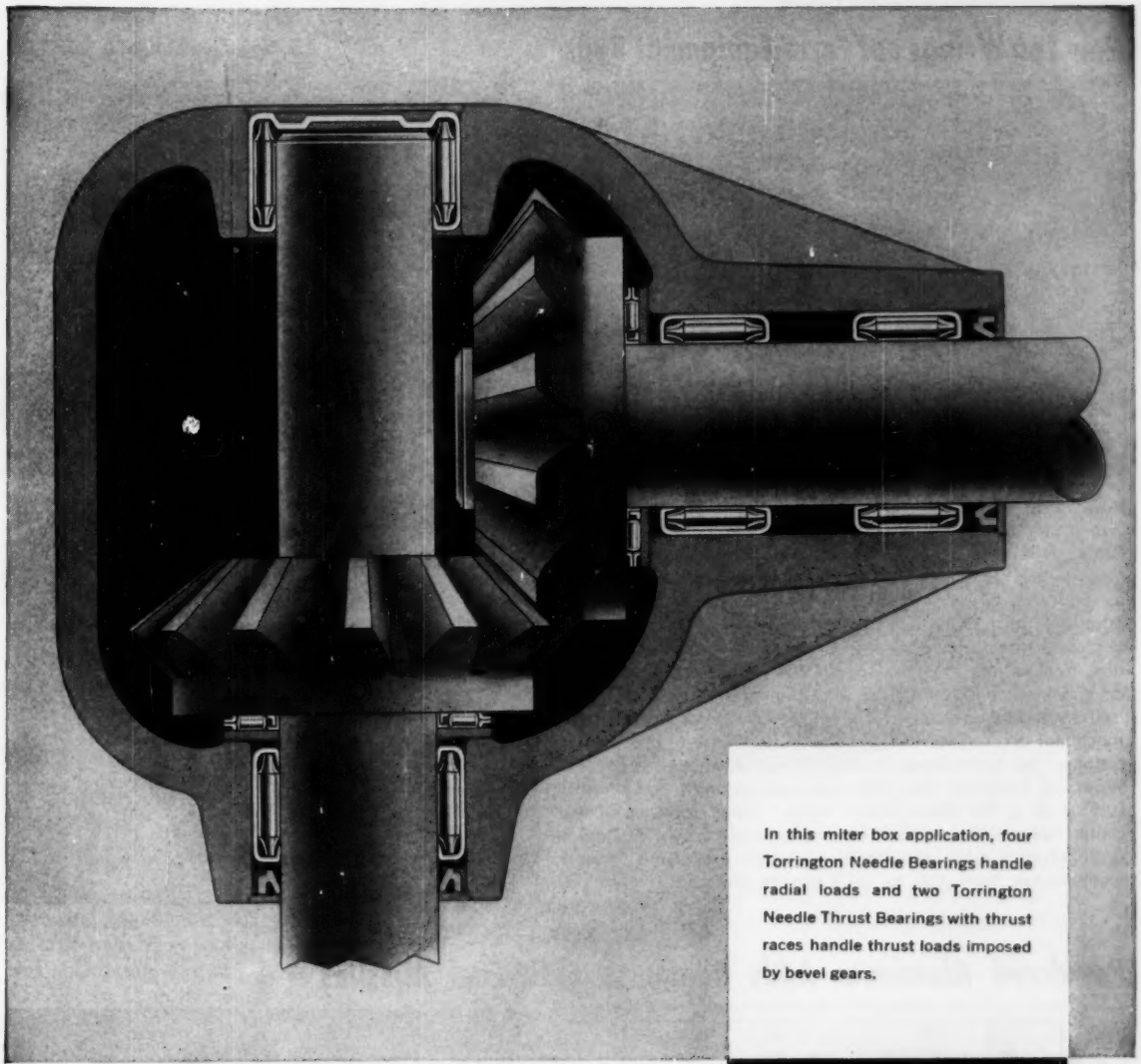
While the foam has no immediate toxic effects, its long-range effects are not yet fully understood. Army researchers are now engaged in "tagging" the polyurethane with a radioactive isotope tracer to learn what happens as it disappears from the fracture site.

It is hoped the substance will greatly reduce length of time of hospital care for the wounded soldier. In the past, at least 60 per cent of casualties have suffered fractures.



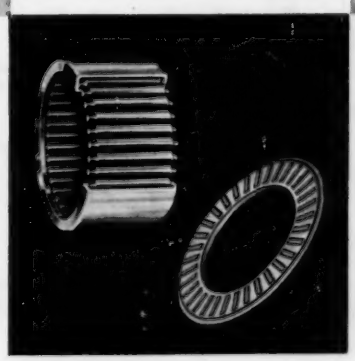
Airborne on Porous Nickel

Photo film, molten glass, or other touch-sensitive stock can ride on air along sintered-nickel conveyors. Porous nickel sheets and shapes, now in production at Corning Glass Works, support the material on a thin cushion of air forced through the pores. A new hydrostatic pressing method makes sheets 12 by 30 in. up to 1 in. thick, or cylinders up to 12 in. diam by 24 in. long. Molds for special shapes can be made. Pores can be any specified size from 1 to 45 mu diam.



In this miter box application, four Torrington Needle Bearings handle radial loads and two Torrington Needle Thrust Bearings with thrust races handle thrust loads imposed by bevel gears.

Perfect Combination for Thrust and Radial Loads



Here's a space-saving, cost-saving way to handle high thrust and radial loads. Just team up Torrington Needle Bearings with Torrington Needle Thrust Bearings!

With their full complement of small diameter rollers, Needle Bearings handle higher radial loads than any other anti-friction bearing of comparable cross section. And Needle Thrust Bearings are only .0781" thick – as thin as an ordinary thrust washer. Together they make a perfect combination of compact, light, rugged anti-friction bearings.

Either type of bearing may be run on hardened and ground adjacent parts to meet minimum space requirements. Or they may be used with standard races available from Torrington. To make the most of this efficient combination, call on our engineering staff for application advice.
The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.

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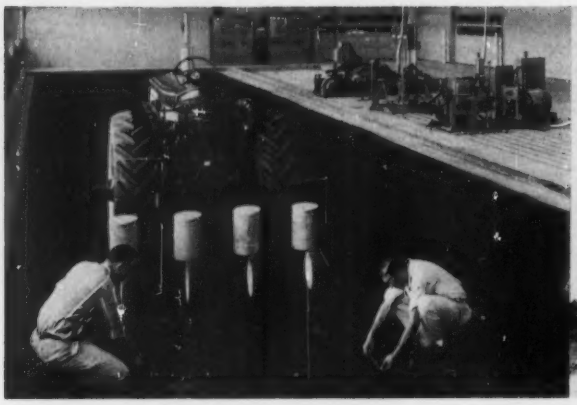
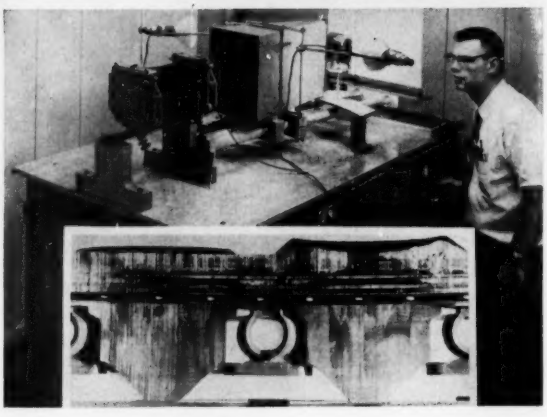
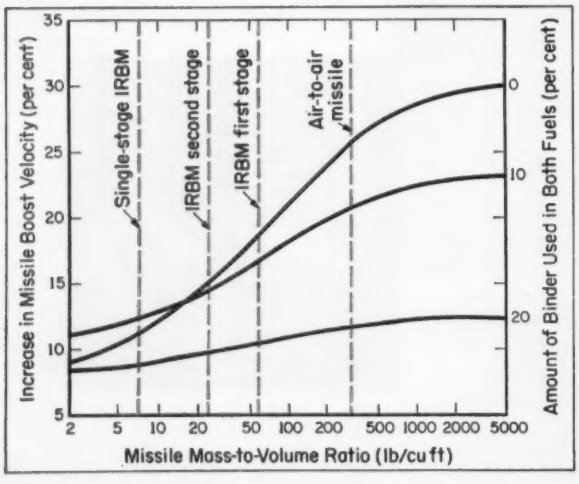
New Lab Wrings out Farm-Equipment Bugs

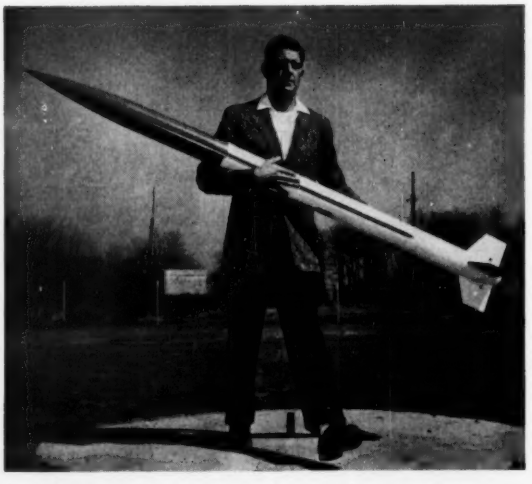




New farm equipment gets rough treatment in International Harvester's new Farm Equipment Research and Engineering Center. Devoted exclusively to design and development of tractors and farm implements, the center boasts an indoor farm (above, left) where equipment studies can be carried out regardless of the weather. Tractor endurance tests are run on a torture track (above right). Driven over a series of raised ribs, tractors receive more punishment on this track than they do in a lifetime of normal use. Instrumentation for the "farm" includes high-speed cameras which record planter valve action, functional accuracy of implements, and damage to bearings or pistons. For piston-wear studies, IH has developed a camera system to "unwrap" the piston and photograph the cylindrical surface as a flat plane (lower right). Other facilities at the center include 15 test cells for engine and carburetor studies and hot and cold laboratories in which environmental test temperatures from 130 to −50 can be imposed.

Powdered Aluminum Adds Range to Solid-Fuel Missiles





Aluminized propellant improves boost velocities of solid-fuel missiles from 10 to 30 per cent, says Atlantic Research Corp., Alexandria, Va., one developer of this type propellant. Studies have shown velocity increases of about 10 per cent in long-range missiles (IRBMs and ICBMs) and up to 30 per cent gains in air-to-air missiles. Since missile range varies approximately as the square of boost velocity, range with the new fuel is about 20 to 60 per cent longer. At left, increase in boost velocity is plotted against inert mass (payload plus airframe mass) per unit propellant volume. Three cases compare gains with no binder in either aluminized or nonaluminized fuel, 10 per cent binder in both, and 20 per cent binder in both. Meteorological rocket (right) developed by ARC to use aluminized fuel carries 12 lb of instruments to an altitude of 249,000 ft. Weight of rocket with payload is 77 lb.

Navy Awards Contract For Nuclear Seaplane Study

Aircraft Predicted Operational by 1964

BALTIMORE—Designs for a nuclear seaplane to use heavy shielding around the reactor will be studied by Martin Co., Baltimore, under a one-year $127,000 Navy contract. Studies to be made will be based on an aircraft using turboprop engines and an indirect-cycle reactor. Navy objects to the direct-cycle engine under Air Force development because, as Vice Admiral J. T. Hayward, Asst. Chief of Naval Operation (R & D) puts it, "It has some very fundamental drawbacks to our problem. It has the divided shield instead of the unit shield. It exposes all of our equipment to radiation. We just cannot live with it."

Although Navy and Air Force nuclear-airplane projects have a 13-year history, the day of nuclear flight by the U. S. is still far in the future. Over $800 million has already been spent (of which the Navy has spent about $12 million), but nuclear aircraft are still millions of dollars away. Commenting on the Navy's goals and program, Adm. Hayward recently told Congress: "We feel by 1964 in our program we will have one (a nuclear-powered operational aircraft) in the air. It could be done sooner in the national program . . . if somebody wanted to do it just . . . for psychological reasons. We are engaged in an orderly R & D program of materials, components, and engine development."

The latest contract brings the total to $1.5 million worth of nuclear seaplane research conducted by the Navy at the Martin Co. since 1953. The Navy's 1960 fiscal year nuclear seaplane program involves a total expenditure of $2 million.

Oops—No Name and Address!

The description of the sequence controller on Page 126 of this issue inadvertently omitted the name and address of the manufacturer. This equipment is made by Automation Engineering Inc., 1214 Royal Ave., Louisville 4, Ky.

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SUSTAINED PERFORMANCE — Twenty years of operation, even under adverse conditions, is not uncommon.

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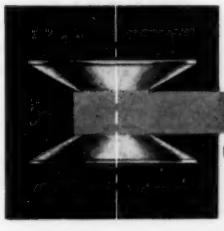
ALTERED STARTING SPEEDS — Speed setting may be adjustable either running or not running.



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Distributors in All Industrial Areas. In Canada—Peerless Engineering Sales, Ltd., Toronto-Montreal

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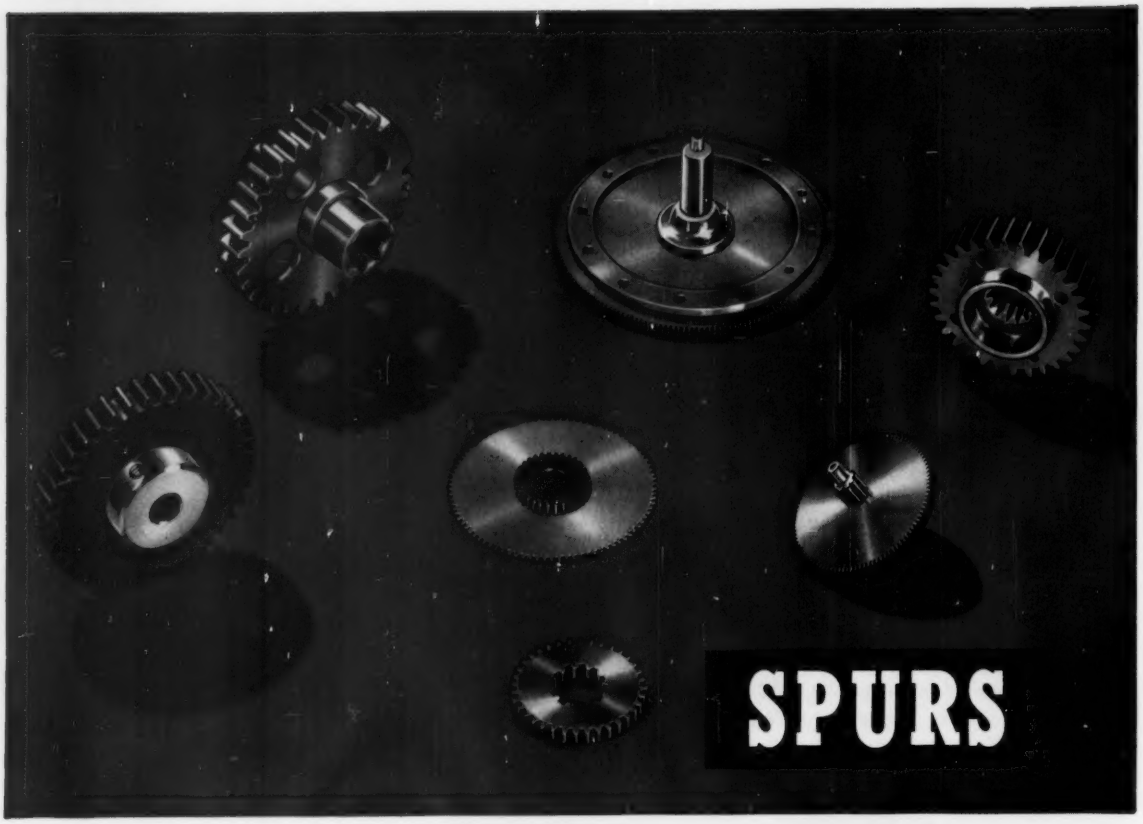

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•

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Reader Information Service

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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AUG. 6, 1959

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412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
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428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

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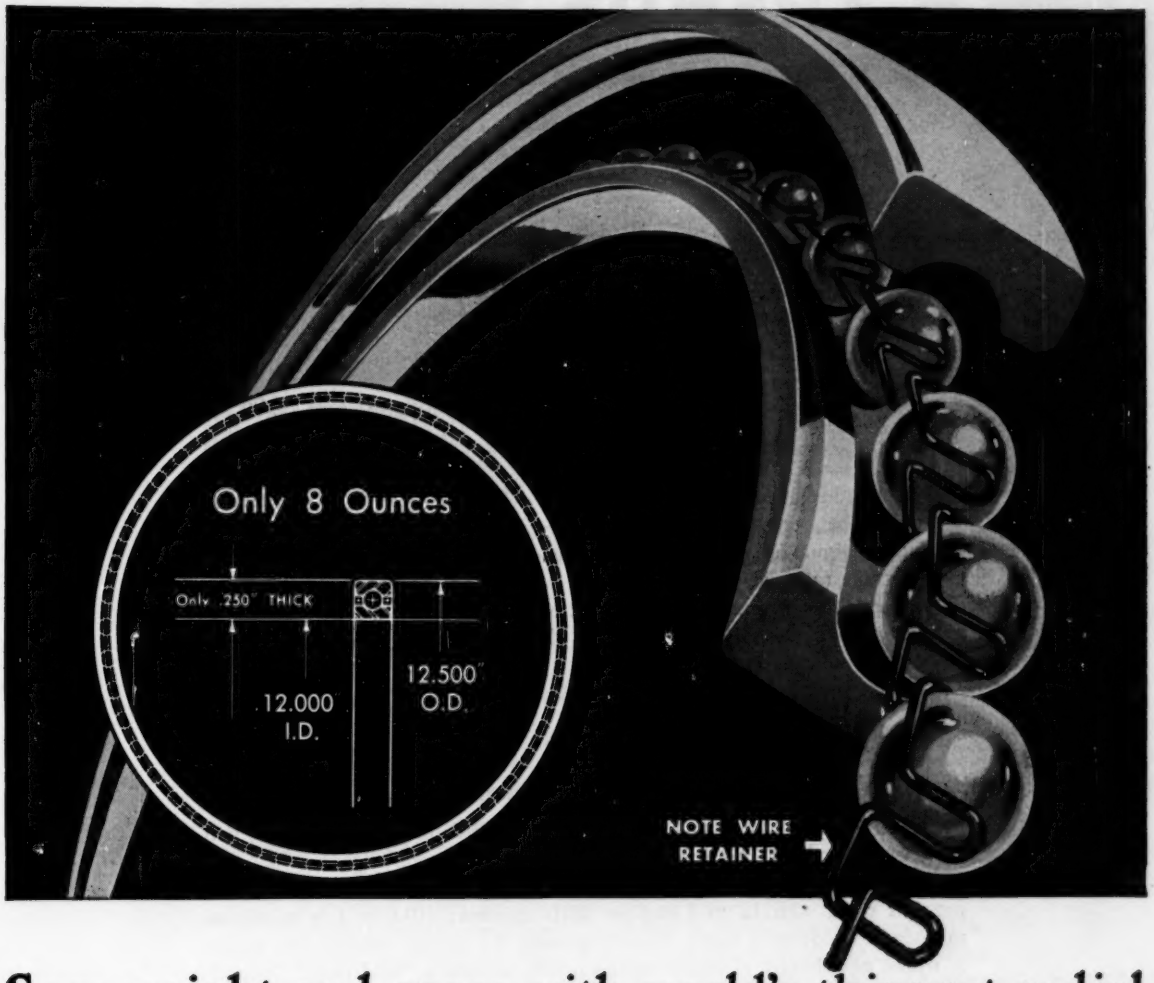

Save weight and space with world's thinnest radial ball bearings—*Reali-Slim* by Kaydon ...now carried in stock in 4" to 12" bores

HERE it is! A *Reali-Slim* radial ball bearing with a wire separator that has just short of a full complement of balls for maximum capacity. What's more, you still get all the advantages of a separator between the balls. This design also gives you a bearing that's light-in-weight and is, without a question, the thinnest bearing ever built in this diameter.

Whatever your product design, there's a small or large diameter *Reali-Slim* bearing that can be the right answer to your thin-section bearing problems.

The radial ball bearing, illustrated here, is *really slim* — 12.000" I.D., 12.500" O.D., .250" thick . . . *and weighs only eight ounces.* It has 9,810 lbs. static load capacity, 1,256 lbs. at 100 rpm. Kaydon is able to produce *Reali-Slim*, high-precision bearings because Kaydon specializes in the unusual.

Kaydon bearing engineers are prepared to give you valuable help with technical, thin-section bearing problems.

For detailed information on Kaydon's *Reali-Slim* line, ask for engineering catalog No. 54-RS3 detailing:

Reali-Slim Ball Bearings — Conrad, angular contact and 4-point contact types in seven standard cross sections from ¼" to 1.000" and in bore diameters from 4" to 40".

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All types of ball and roller bearings — 4" bore to 178" outside diameter . . .

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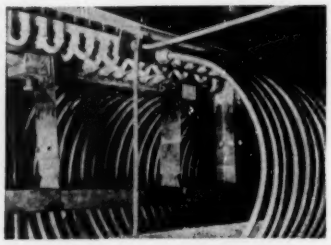
Circle 413 on Page 19

aluminum recovers air-conditioner fumble

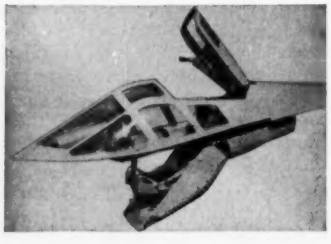


Aluminum is on the comeback trail in air conditioners. Two developments solve problems that shelved aluminum air-conditioner coils eight years ago. With zinc solder and flux developed by Aluminum Co. of America, aluminum joints can now be soldered at 725 F. Aluminum tubes suffering from electrolytic action in the presence of copper fittings can be protected by sacrifice fins of zinc-aluminum alloy. Alcoa recommends using aluminum fittings wherever possible to avoid severe electrolytic action. Two-year tests already conducted are the equivalent of eight years of normal use, says Alcoa. Air-conditioner manufacturers are field-testing about 3000 units equipped with the economical soldered-aluminum tubes.

fuel additives may quiet '64 car engines

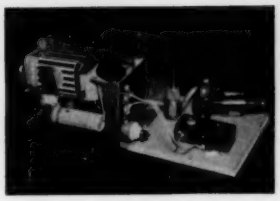
Big boost in car-engine compression ratios predicted for five years hence will require a new brand of gasoline, according to the nation's leading fuel specialists. They expect the average 1964 powerplant to have an 11 to 1 compression ratio, with 12 to 1 engines fairly common (10.5 to 1 is maximum in today's production cars). Present penalty for higher compression ratios: A whole new family of exotic engine noises, including "wild-ping," "pounding," and "rumble." The new sounds can be eliminated with higher octane, but by present techniques, a rise of several points in octane rating costs more than the traffic will bear. Fuel men say that new additives are needed and predict that 1964 gasoline will be practically synthetic—90 per cent of the fuel components will be materials not present in the original crude oil.

combat pilots will get capsule escape system



Increased comfort and safety for pilots of Navy's front-line fighter aircraft is the object of an advanced R&D contract awarded to Chance-Vought Aircraft. Goal of the project is development of a sealed capsule in which the pilot will no longer be personally burdened with oxygen mask, pressure suit, parachute, bailout oxygen bottles, life jacket, raft, and other survival gear. In emergency, the entire capsule will separate from the aircraft, and will be boosted by rockets, stabilized by retractable fins, and decelerated by force-sensing drag brakes, until a first-stage parachute opens at 500 mph. A cluster of 'chutes will open at 220 mph for final descent.

spark-ignition coming for all gas appliances

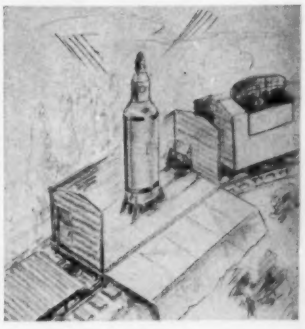


Because the American Gas Association has a lot to say in setting standards for gas appliances, its spark-ignition research program is probably the first step in more general use of this type ignition. Already developed is a 4000-v, 8000-cps spark system that operates from 6-v nickel-cadmium batteries via a solid-state inverter. Because batteries are used rather than house current, the system will work even when electric power lines are down. It is also adaptable to picnic stoves using bottled gas. The batteries can be recharged from 110-v, 60-cycle line current.

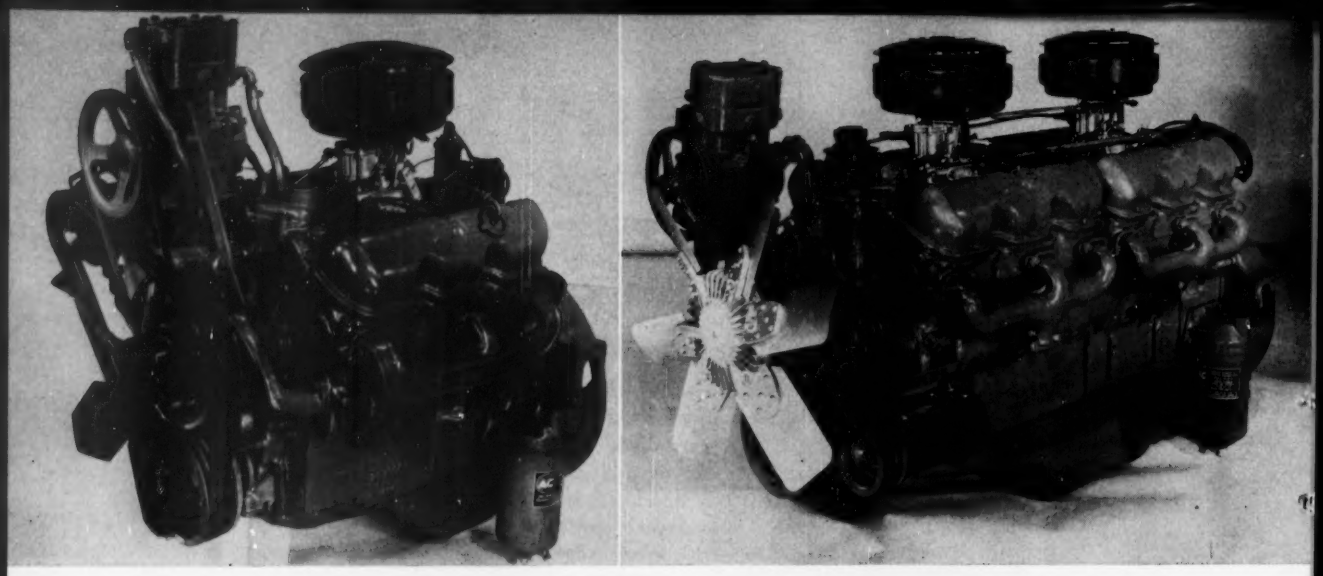
molten lead and metal powders form unique alloy family

Mixing powdered metal with molten lead in a rotating crucible, Battelle Memorial Institute has opened the door to a new type of alloy. Properties of the lead "cement" are combined with those of the powdered-metal "aggregate" in the finished product to make an attractive collection of engineering qualities. For instance—lead is an effective shield against gamma rays. Adding boron, which effectively stops neutrons, makes a "lead cemented" alloy which is a better shield against combined radiation. Besides boron, Battelle has been able to mix six metals with good results: Cobalt, copper, iron, molybdenum, nickel, and tungsten. Some of these have especially desirable properties for certain applications, but are brittle. In a matrix of soft lead they become workable without losing their own special qualities. Potential applications include bearings, seals, and high-temperature gaskets.

box-car launch pads considered for Minuteman



Defense Department is seriously considering a plan to integrate the nation's 390,000 miles of railroad track into a ballistic-missile launching system. Disguised as conventional freight carriers, missile trains would be designed to accommodate the 55-ft, solid-fuel Minuteman missile which will be ready in 1963. Mobile launch platforms, capable of "disappearing" among the 3000 other trains that run daily on the nation's rail lines, would thus eliminate the "sitting-duck" aspect of present hardened bases. All targeting data would be preplanned around mileposts strung beside the railroad track. Preliminary cost estimates prepared by Bethlehem Steel Corp. and Paul Hardeman Inc. indicate that cost of one missile train would be considerably less than cost of a single underground silo.



Three V-6s and one V-12 make up GM's new family of gasoline truck engines. Biggest of the 6s (401 cu in.) and the powerful V-12 (twin 351-cu in. V-6s) are shown above. A 305-cu in. V-6 completes the line-up. Preliminary engine specifications are listed at right.

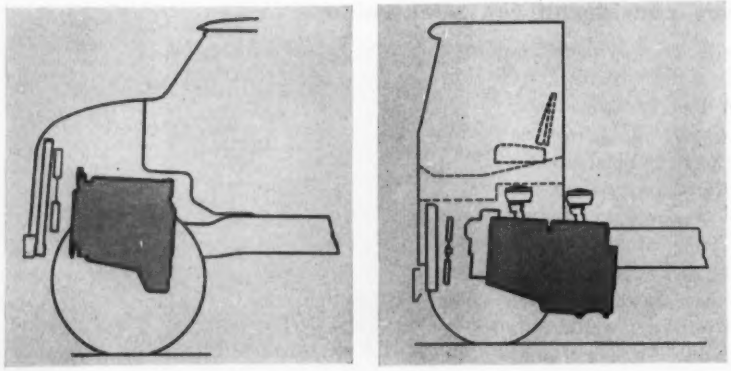
Displacement (cu in.)	305	351	401	702
Bore & stroke (in.)	4.25 x 3.58	4.56 x 3.58	4.88 x 3.58	4.56 x 3.58
Power, max (bhp)	165 @ 3800	180 @ 3400	205 @ 3200	275 @ 2400
Torque, max (lb-ft)	...	...	370 @ 1400	630 @ 1600 to 1900

GM's V-6 *A powerful precedent in truck-engine design*

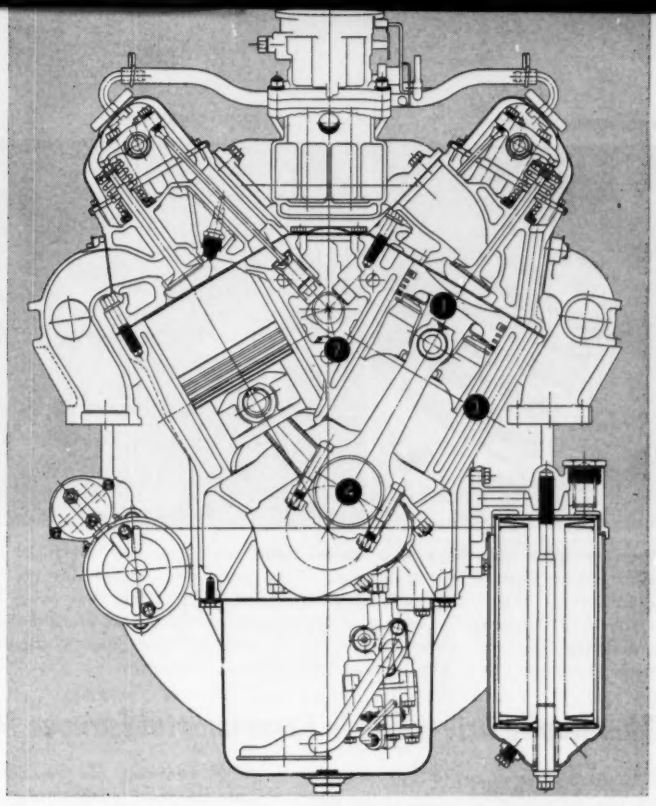
DRAMATIC CHANGES in engine design are few and far between. On this count alone, GM's brand new family of V-6 gasoline truck engines will attract plenty of attention. By all indications, however, the V-6 is not only a lively departure from conventional design, it is a solid contender in the field of heavy-duty truck engines. GM is building three basic versions of the V-6 (305, 351, and 401 cu in.) plus one V-12 (twin 351 V-6s) to bracket all power requirements in its GMC truck line.

The new engines easily pass the first test of a truck engine: They develop maximum torque at moderate speed. The 401 V-6, for example, peaks at 1400 rpm. A comparable V-8 produces maximum torque at about 2500 rpm. This gives the V-6 a big edge in life expectancy. In fact, based on extensive dynamometer and road tests, GM engineers give the new engine "three to four times the durability" of present in-line 6s and V-8s. The V-6 will be coupled with a specially designed five-speed transmission and a single-speed axle, instead of the usual 8-10 speed transmission.

The V-6s are smaller, heavier, and more rugged than comparable V-8s. The crankshaft in the 401



Compactness of the new engines provides greater latitude in cab design. V-6, left, is shorter than previous GM V-8s or in-line 6s. It fits under a short hood, reducing cab length significantly. Low contour of the Twin Six, right, also permits a reduction in cab length. A comparable V-8 is substantially higher, not nearly so adaptable to various cab designs.

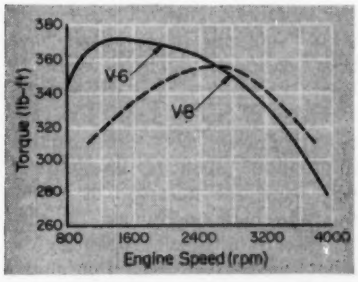


V-6 weighs 110 lb, versus about 65 lb for a comparable V-8 shaft. In addition, GM engineers point out that the 60-deg V-6 design imparts extra rigidity to the crankshaft because crankpins overlap due to the peculiar firing order of the engine. The engine has about 0.002 in. of unbalanced motion which is absorbed by rubber mounts, so it is almost perfectly counterbalanced. Its oversquare design (bore dimension exceeds stroke dimension) is unusual insofar as truck engines are concerned and contributes further to the V-6's longevity.

Mechanical valve lifters are used on the V-6, hydraulic on the V-12. Valve life on all engines is considerably enhanced because valves are spread farther apart, with plenty of water-cooling space in between. There are no adjacent exhaust valves in the valve train—length of the V-6 engine is limited by length of the crankshaft rather than by the number of valves, as is the case on V-8s. Water flow rate is just short of phenomenal: 180-200 gpm. Oil flow rate is also high: 14 gpm at 60 psi in V-6s; 17 gpm in the V-12. This compares to 5-9 gpm at 30-40 psi in the usual gear-type pump.

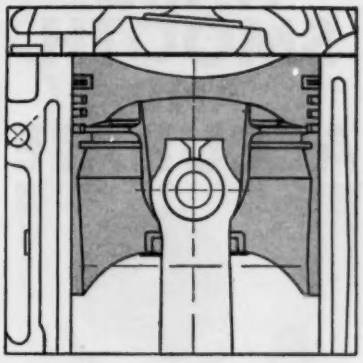
As for cost, the V-6 will probably be priced higher than in-line 6s, but less than V-8s. Interchangeability of parts is the big factor in minimizing both manufacturing and operating costs. Valves are the same in all engines, except for heavier units in the 401. Common connecting rods and two different heads serve the entire line. Crankshaft bearings are the same throughout. GM estimates that it will be able to cut its replacement-parts inventory by 40 per cent, a saving that would pass on to fleet owners also.

Chances are good that GM will introduce the new engines sometime during the 1960 model year. Significant truck redesign may accompany them.

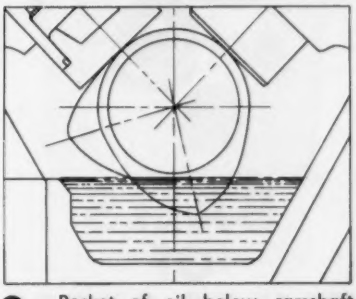


Peak torque is developed at 1400 rpm by the 401-cu in. V-6. Comparable V-8 would develop maximum torque at about 2500 rpm.

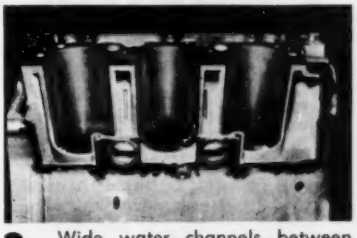
V-6 fine points . . .



1 Shallow spherical cup in the top of each piston forms part of the combustion chamber. Steel inserts reduce wear of the upper ring and groove.



2 Pocket of oil below camshaft lobes gives valve lifters "immediate" lubrication.



3 Wide water channels between cylinder bores help make the V-6 a cool-running engine. Water flows through the heads at rate of 120 to 200 gpm.

4 60-deg V design imparts extra rigidity to the crankshaft, since crankpins overlap due to peculiar firing order of the engine.

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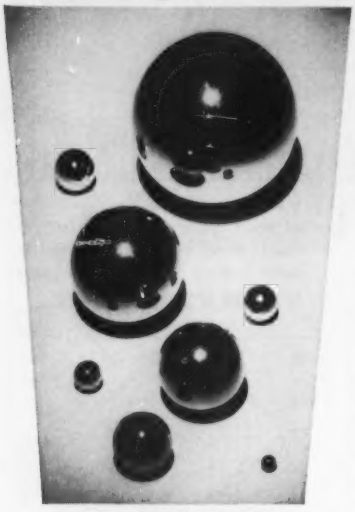

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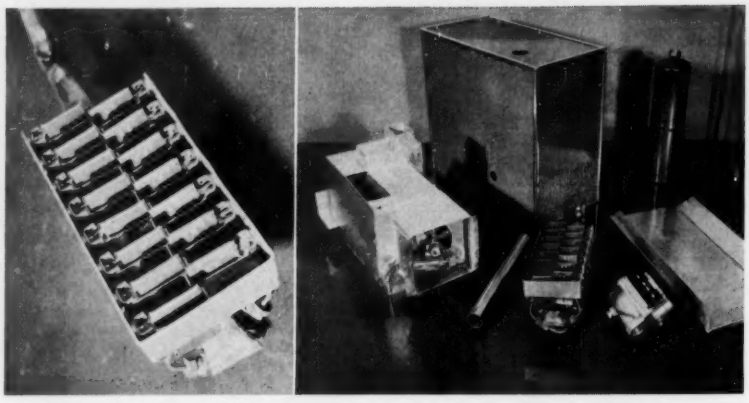
3676 Jackson Road, Ann Arbor, Michigan

Circle 414 on Page 19



Thermocouples imbedded in a burner head could generate electricity to power a forced-air furnace fan or blower. They could also actuate the room temperature-control circuit. Gas furnaces designed to produce their own electricity would function normally in case of utility power failure. No unusual components are needed by the demonstration model, (right). Components shown include heat exchanger, flue duct, burner, and pressure regulator.

Thermopile Drives Fan in Experimental Furnace Model

CLEVELAND—Home-heating systems of the future may use gas to run electric blowers, as well as to furnish heat. An experimental small-scale forced-air furnace, recently demonstrated at American Gas Association's Cleveland laboratory, furnishes power for fan operation by direct conversion of heat to electricity. Thermocouples that do the job are imbedded in the burner head.

In the demonstration model, the burner is proportionately larger than it would be in a production furnace. "The purpose of the unit is to demonstrate the principles involved. High efficiencies were never intended in this model," says W. B. Kirk, AGA's chief research engineer. Efficiencies of forced-air furnaces are quite high. Thermocouples are not expected to decrease efficiency considerably.

Although the furnace program is still in the research stage, several appliance manufacturers are reportedly considering best means of applying the research to future models of their appliances.

Auto Builders Agree On Production-Tool Standards

Modular Units Increase Useful Machine Life

DEARBORN, MICH. — More fluid auto design may result from agreement on production-tool standards recently reached by automakers and tool builders. The "building block" production-tool concept has long been advocated by automakers as a means of reducing obsolescence costs due to design changes.

In practice, the new standards will permit replacement of one or more sections of a production line to adapt the line to a newly designed part without changing the whole line. This means auto designers will have more freedom to redesign without waiting for major retooling.

Henry C. Daum of Ford Motor Co., chairman of an industry-wide study committee, emphasizes that the standards are not intended to dictate design features to machine tool builders. Only a limited number of standard specifications have been included. These refer to height of loading table, dimensions and faces of tool columns, and various mounting slots and saddles. Eliminating artificial obsolescence will speed the purchase of expensive automatic production machinery, according to spokesmen for the auto industry. Other producers have shown interest in the concept developed originally by Ford, General Motors, Chrysler, and International Harvester.

College of Engineering Goes Professional at OSU

Pre-Engineering and Professional Divisions Make 5-Year Program

COLUMBUS, OHIO — Ohio State University's College of Engineering has been reorganized along the lines of medical or law schools. Effective with the forthcoming autumn quarter, the five-year program will consist of a pre-engineering division for the first two years and a professional division for the last three years.

Pre-engineering studies — which may be completed at OSU or another school offering a comparable curriculum—will include English, mathematics, physics, chemistry, engineering drawing, and engineering mechanics, as well as the humanities and social sciences, physical education and military science.

Dean Harold A. Bolz of the College of Engineering commented, "The new curriculum will provide a two-year preparatory period wherein students may reflect more fully upon their choice of a career. . . . The engineering faculty . . . feels it (the curriculum) will have a significant influence in attracting to engineering in their third year many capable students who did not seriously consider engineering at the time they entered college, or students who preferred to do their first two years of college work in a liberal arts school or in a community college near their homes."

Dean Bolz also observed that all the new professional division curricula place greater emphasis on both breadth and depth in the engineering sciences, mathematics, and basic science at the expense of "know-how" courses on specific types of machinery or processes. "However," he said, "with the five-year program it has been possible to place greater emphasis on engineering systems courses than is usually possible in a four-year curriculum."

As in the past, superior students will have the opportunity to spend their final year in the graduate school and receive both bachelor's and master's degrees at the end of the five-year period.

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Waterman representatives are in all principal cities. Write for Waterman Solenoid Valve Catalog No. 2000, and for Waterman Flow Regulator Catalog No. 1001.

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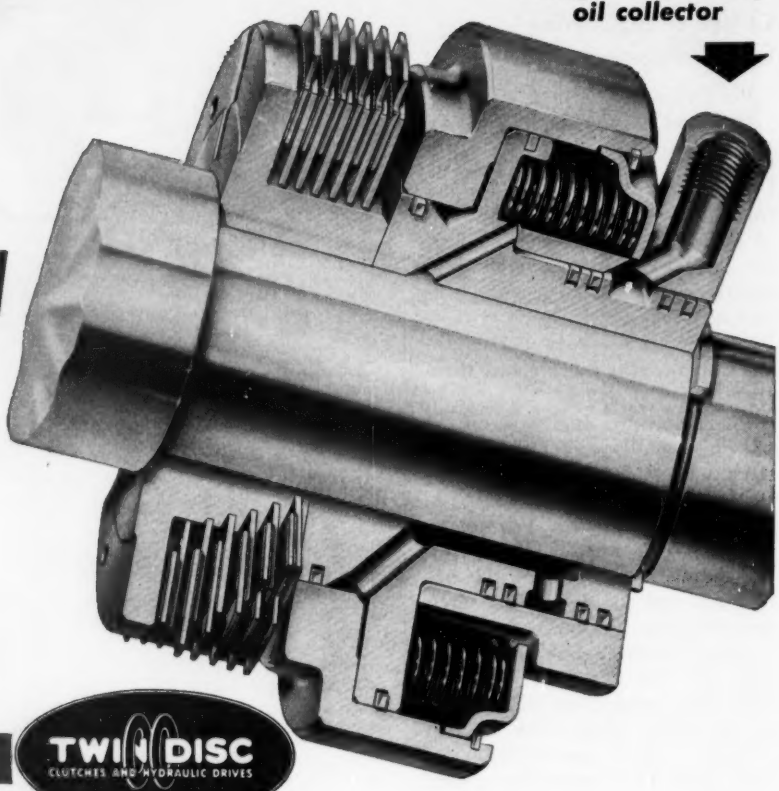
Waterman Engineering Company, 725 Custer Ave., Evanston, Illinois

WATERMAN ENGINEERING COMPANY

Circle 415 on Page 19

Twin Disc Oil-Actuated Multiple-Plate Clutches

Now available with integral stationary oil collector

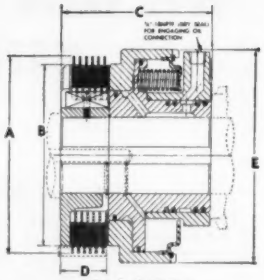


TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

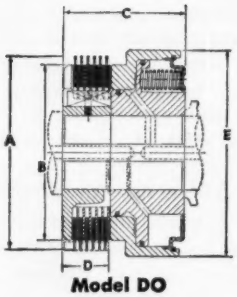
Clutch failures and burn-outs are virtually eliminated in these new wet-type Twin Disc Clutches. No adjustments are needed because ram travel compensates *automatically* for plate wear.

Designed for machine tools and similar applications, these units are built to run in oil and are actuated by oil pressure of 100 to 300 psi. Model DOC (shown above) has an around-the-shaft oil collector connected by a ¼" line. Model DO is identical except that the oil collector is omitted, shortening the clutch somewhat.

Compact design, smooth performance, long wear—with no adjustment problems—these benefits are available *now* in Twin Disc Oil-Actuated Multiple-Plate Clutches. Write for Bulletin 314.



Model DOC

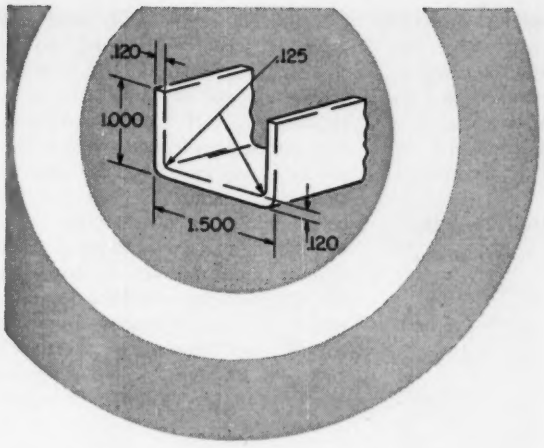


Model DO

Model No.	Torque Capacity Lb.-ft.	Hp Capacity	Max. Allowable Rpm		A	B	C (length)	D	E
			With Hydraulic Balance	Without Hydraulic Balance					
DO-403	37	9	5000	2700	3.31	3.00	2.580—2.566	1.02	3.80
DOC-403			5000	3480			3.500—3.486		
DO-403½	95	20	5000	2680	3.81	3.50	2.892—2.872	1.17	4.42
DOC-403½			5000	3500			3.780—3.766		
DO-604	130	31	5000	2670	4.38	4.00	3.255—3.241	1.26	4.80
DOC-604			5000	3660			4.160—4.142		
DO-605	330	58	4500	2270	5.90	5.00	3.447—3.429	1.35	5.90
DOC-605			4500	3070			4.267—4.249		
DO-706	435	180	3750	1815	6.56	6.00	3.981—3.963	1.60	6.90
DOC-706			3750	2560			4.822—4.804		
DO-707	690	137	3250	1790	7.62	7.00	4.697—4.679	2.12	8.00
DOC-707			3250	2550			5.540—5.522		

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

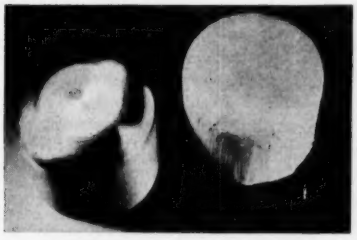
BRANCHES OR SALES ENGINEERING OFFICES: CLEVELAND • DALLAS • LOS ANGELES • NEWARK • NEW ORLEANS



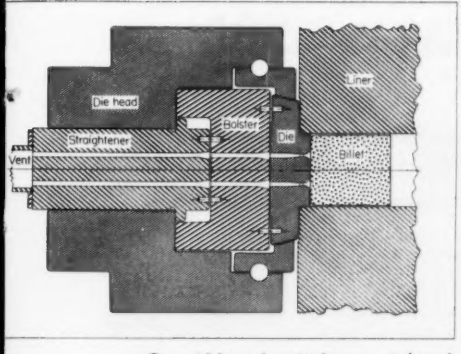
Plus qualities of beryllium are impressive—weight is about the same as magnesium . . . stiffness is 50 per cent higher than steel . . . strength approaches that of good aluminum alloy. But the "space metal" is tough to work and is extremely brittle. Here's how Northrop Corp. is overcoming these problems to develop an aircraft-quality extrusion.

Target: Beryllium Extrusions

JOHN A. VAN HAMMERSVELD
General Supervisor
Design Support Branch
Norair Div., Northrop Corp.



1 **Attempts to bare extrude** beryllium began with sintered billets. Brush Beryllium Corp. supplied QMV reactor-grade billets (shown) to Nuclear Metals. Beryllium Corp. produced billets in its own facility.



2 **Although a light metal,** beryllium is extruded by "streamline flow." High resistance to deformation leads to use of heavy tooling. Sketch shows straightener that cools and straightens the exiting extrusion.

FLIGHT-VEHICLE designers have big plans for beryllium extrusions. Three out of four builders of the next round of missiles and spacecraft will use the "space metal" in primary flight structures . . . and they'll do it within five years.

Working under an Air Materiel Command contract, Norair Division of Northrop Corp. set out in early 1958 to find beryllium-extrusion types, sizes, and configurations most needed by the airframe industry. The program was also designed to search out compositions most likely to make good extrusions, and to make an attack on the myriad of problems blocking production. Aim was to develop methods for bare extruding beryllium to aircraft quality without recourse to expensive "canned" or "filled billet" techniques.

From a Survey: A Target

Surveying the industry, Norair found an expected diversity in requirements. Minimum extrusion lengths desired ran from 5 to 20 lineal feet. Top prices users were willing to pay ranged from $30 to $250 per pound. Anticipated temperatures started at a low of −400 F, reached a high of 1400 F. Desired mechanical properties, as would be expected, were generally above those available in present-day beryllium compositions.

From the results of the survey, Norair developed a composite of industry requirements for a "target" Phase I extrusion (above). Quality standards set for the initial 20-ft extruded section were:

- Straightness: 0.0125 in. per ft
- Twist: (circle size) ½ deg per ft; 5 deg. max
- Angularity: (less than 0.188 in. thick) ±2 deg at any point of measurement
- Length: ± 0.250 in.
- Flatness: (crosswise dimension) 0.004 in. per in.
- Surface roughness: 100 mu in. general

Besides satisfying aircraft-industry requirements, the target channel introduced many extrusion variables which had to be understood and mastered. Phase II and Phase III shapes were not selected at this point because early successes in extrusion (and possible changes in aircraft-design philosophy) might conceivably alter requirements.

Competitive participants selected by Norair for Phase I extrusion operations were Nuclear Metals Inc., Concord, Mass., and Beryllium Corp., Reading, Pa.

To establish a foundation for future material requirements, Norair—in co-operation with the parti-

Target Composition

Element	Quantity
Carbon	0.15% max
Iron	*1500 parts per million max
Nickel	0.08% max
Copper	0.05% max
Aluminum	0.15% max
Manganese	0.03% max
Silicon	0.10% max
Chromium	0.05% max
Magnesium	0.05% max
Beryllium Oxide	1.50% max
Beryllium	Remainder

*700 parts per million desired.

3 **Cobalt-chromium extrusion** dies stood up best under the abrasive action of beryllium, did not "wash out" catastrophically. Evolution of U-channel dies is shown here. Better lubrication may make use of less expensive tooling practical.

cipating contractors, Defense Metals Information Center of Battelle Memorial Institute, and Brush Beryllium Corp.—prepared specification ND-161A covering beryllium extrusion materials. One very important aspect of this composition is the rigid control placed on maximum "tramp" elements.

Iron, in particular, is known as a potent strengthener, as well as an important embrittler of sintered-billet beryllium.

Quality: Encouraging

Production of round rods was the initial step in attempts at bare extrusion. First rods were poor indeed, but development of a scientific approach finally gave relatively long lengths of good, round rod.

Next step was the transition to U-channels, and early results were quite discouraging. Introduction of the more complex extrusion variables, coupled with unsolved die and lubrication problems, gave horribly rattlesnaked, badly torn channels. The only visible encouragement was that the general channel shape was assumed, and the material remained in a single piece after exiting from the die.

Continued refinement of extrusion processes, tooling, and lubrication finally gave extruded U channels several feet in length. Although production of 20-ft aircraft-quality channels has not yet been accomplished, it is believed that these will result from recent developments.

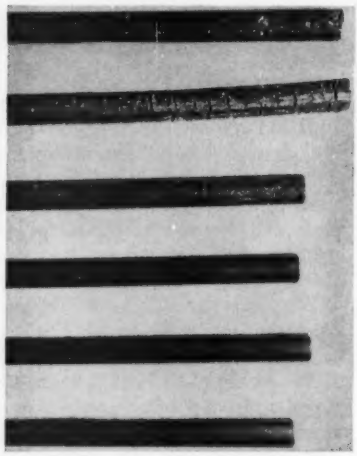
Strength: On Target

Phase I extrusions were tested against target mechanical properties in the longitudinal direction (transverse requirements were not established). Elongation and reduction of area desired were based on results achieved from experimental beryllium extrusions produced by "canned" or "jacketed" techniques.

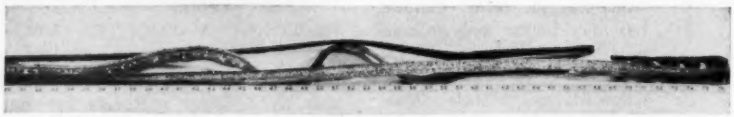
How Properties Measured Up

Property	Target	Results
Ultimate tensile strength (psi)	60,000	80,700
Yield strength (0.2% offset) (psi)	35,000	54,100
Per cent elongation (in 2 in.)	10	3.5 to 6.0
Per cent area reduction	10	Too small to measure

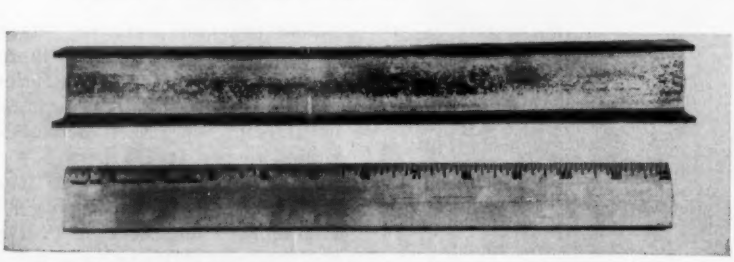
Significant reduction of area will probably not be realized unless specific methods for control of grain orientation are developed. In most applications, lack of area reduction does not constitute a deterrent to the use of beryllium. Also, the current elongation values are not too far below those obtained with heat-treated, high-strength alloys of magnesium and aluminum. In any case, the attributes of beryllium far outweigh its disadvantages. In most critical applications, its shortcomings will undoubtedly be compensated for in the design of air-space vehicles.



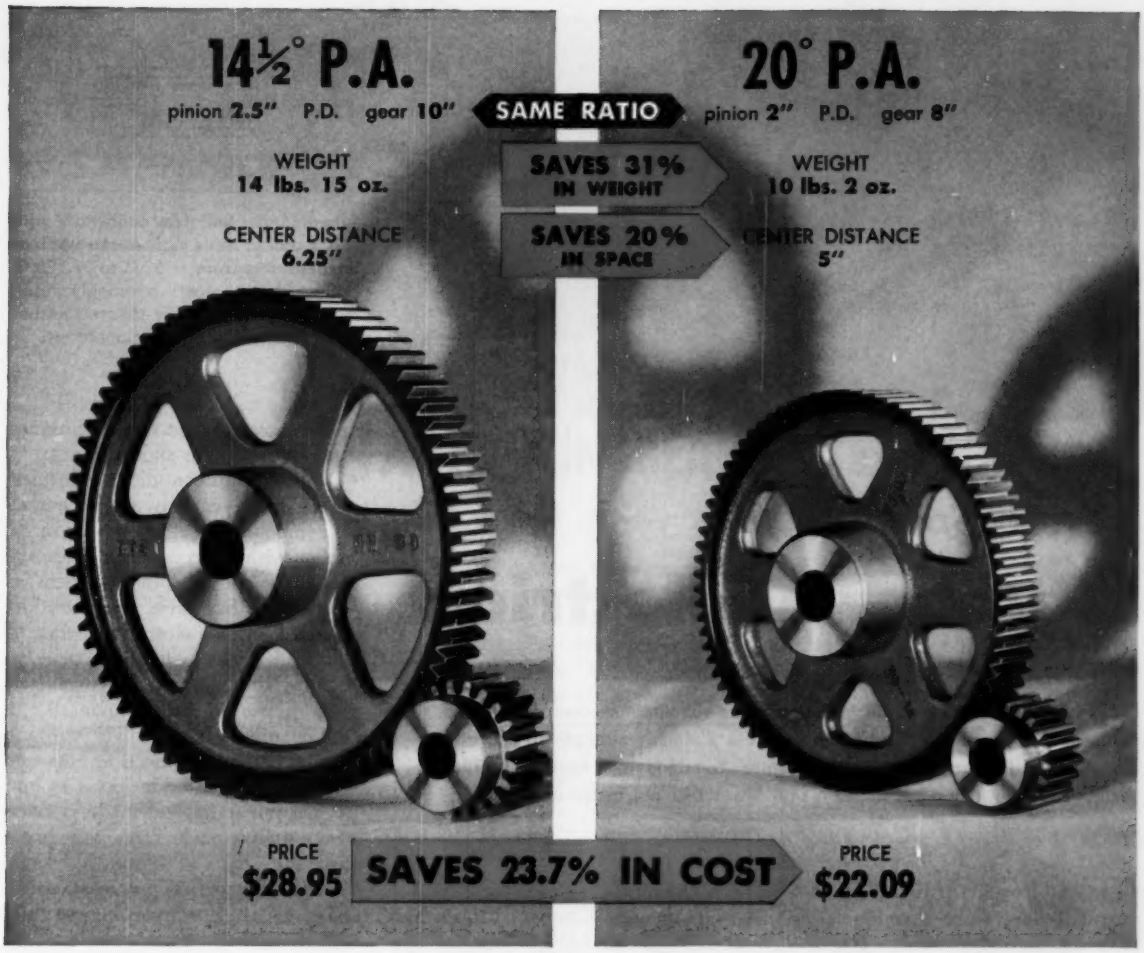
4 **Production of round rod,** first step toward the "target" channel, was mastered with these successive improvements in quality (top to bottom). Before extrusion, each billet was heated to desired temperature (1635 to 2000 F), removed from the furnace, and rolled in a glass-powder lubricant. A soft copper-nickel "nose," placed in front of the beryllium billet, was found to expedite starting of the streamline flow pattern.



5 **Transition to U-channel extrusions** after round sections were mastered gave discouraging results like this one. Although badly torn and rattlesnaked, the general channel shape was evident and the material remained in a single piece after leaving the die. Optimum extrusion ratios were found to lie between 20:1 and 35:1. Extrusion speed appeared to have no visible effect on quality.



6 **Continued refinement** of processes, tooling, and lubrication finally gave an extruded channel section with quality comparable to this 1-ft section. Black patches on the surface of the part are glass-lubricant particles remaining after extrusion and are easily removed by etching, vapor blasting, etc. Further improvement—and the target 20-ft lengths—will follow with improvement in beryllium ductility, lubricants, and lead-in pieces. Norair is continuing its study of best temperatures, reduction ratios, extrusion speeds, and die design.



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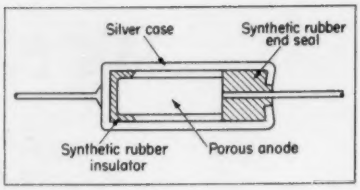


Subminiature tantalum capacitors with IERC's rubber seals and spacers work at temperatures from −65 C to +125 C. Unlike some other commonly used materials, the specially tailored rubber takes relatively little permanent set.

New Strength for

Rubber Dielectrics

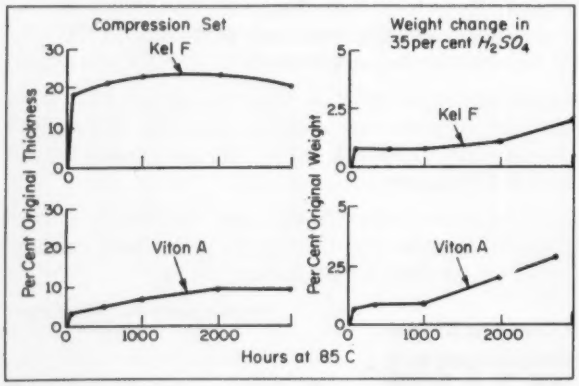
Rubber is coming back as an insulator in the subminiature-component field. Conventionally processed rubber hadn't the dielectric strength to separate closely-placed charges in microminiature components. New processing techniques give it needed strength and lower the loss factor as well.

PRECISION RUBBER PARTS—so small they make a common pin look like a nail (above)—are now being mass produced for subminiature electronic components. Rubber is well suited for service as spacers and seals: Elasticity is high; permanent set is low; it resists deterioration by a wide range of corrosive chemicals.

Up to now, however, rubber has been neglected for this kind of application. In the usual commercial grades—with conventional vulcanizing and curing agents—rubber has low dielectric strength and high loss factor. Industrial Electronic Rubber Co., Solon, Ohio, has come up with new processing techniques that correct these shortcomings:

- By using silicon dioxide instead of the usual carbon reinforcement in compounding, they've produced rubber with dielectric properties approaching those of more expensive elastomers. Several of the new compounds have a dielectric constant of 2.25 and a loss factor of 0.002.
- Since the material is vulcanized with nonsulphuric compounds, it can be used next to silver without causing tarnish.
- By holding chloride levels as low as possible, they've made service against silver-oxide films very practical.

High degree of miniaturization being sought for today's electronic components demands elastomer parts with close tolerances. IERC now make rubber bushings as small as 0.050 diam by 0.030 high. Even smaller ones are on the way. Color coding gives quick, easy identification of base stock used.



Low permanent set and inertness make these elastic materials reinforced with noncarbon compounds valuable as seals against many corrosive chemicals. Specially processed Kel F, recommended for seals that must resist strong oxidizing acids, demonstrates high mechanical strength and maximum elasticity. Viton A base stock shines where critical properties are low compression set, ozone resistance, high-temperature strength, abrasion resistance.

Typical Characteristics

Property	Viton A*	Kel F*
Temperature Range (F)	− 55 to + 175	− 55 to + 125
Tensile Strength (psi)	1500	3100
Elongation (per cent)	110	440
Modulus	1350 (at 100 per cent)	1130 (at 300 per cent)
Dielectric Strength (v/mil)	600	770

*Base stock fortified with inorganic silicon dioxide and vulcanized with nonsulphur catalysts. Chloride levels closely controlled.

TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

One in a series of technical reports by Bower

BEARING BRIEFINGS

ROLLER GUIDANCE– VITAL FACTOR IN BEARING LIFE

Roller guidance has been established by the Anti-Friction Bearing Manufacturers Association as a major rating factor for roller bearings. There is a direct relationship between this factor and the life and capacity of a cylindrical roller bearing under load.

Figure 1 illustrates the results of a loose fit between a roller and the guiding ribs of the raceway. Because of lack of guidance by the ribs, the roller is free to skew and skid under load. Such a condition invariably leads to early bearing failure.

To achieve close roller fit and proper roller guidance, Bower precision grinds each bearing race on specially designed centerless grinders. In this operation, Bower positions the integral raceway ribs *from the theoretical centerline of the bearing*. This method produces bearings with high dimensional accuracy and perfect symmetry.

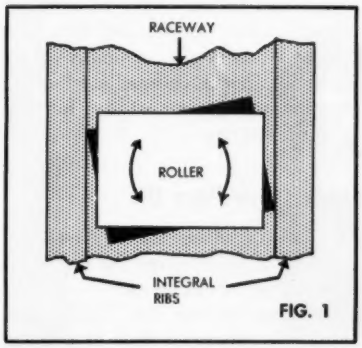
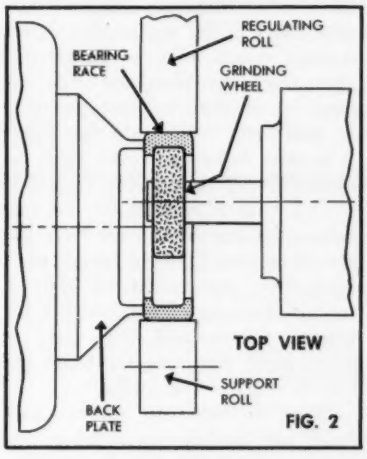
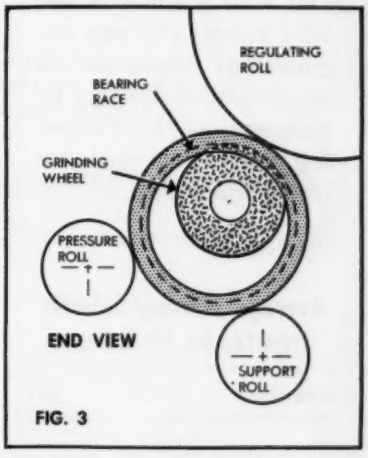


Fig. 1. Loose fit in raceway means poor roller guidance. Roller can skew and skid under load.

In addition, the close tolerances held in grinding the roller track and integral guiding ribs give Bower cylindrical roller bearings the ability to *take thrust in any direction*. A Bower cylindrical roller bearing has thrust capacity of from 10-15% of its rated radial capacity!



Figures 2 and 3 diagram the centerless grinding method used to finish Bower raceways. Use of this technique assures not only optimum roller guidance and maximum bearing life, but also virtually eliminates bearing runout. BEARING SYMMETRY WHICH RESULTS FROM THIS TECHNIQUE PERMITS ACCURATE SHAFT LOCATION REGARDLESS OF HOW THE OUTER RACE AND ROLLER ASSEMBLY ARE INSTALLED. IT COMPLETELY ELIMINATES THE POSSIBILITY OF IMPROPER INSTALLATION.



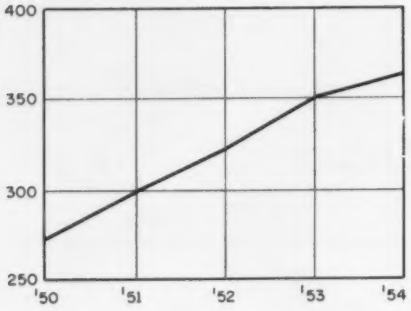
★ ★ ★ ★

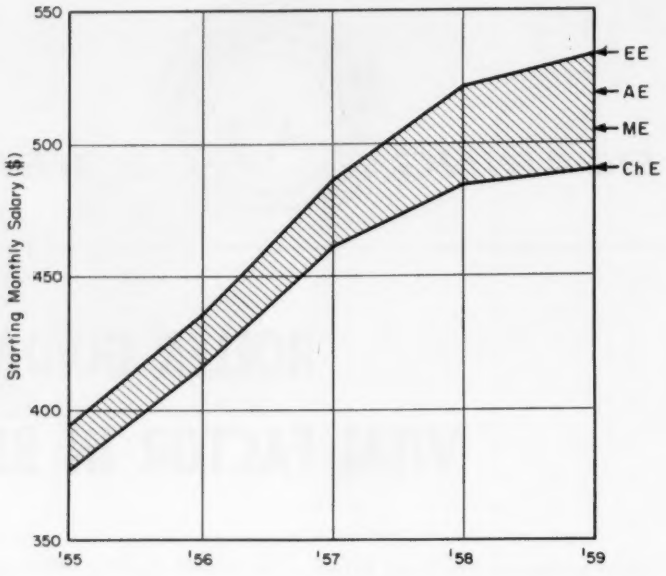
Whatever your bearing needs, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION – FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

Circle 418 on Page 19





ENGINEERS' STARTING SALARIES

Up again in '59

Our annual check of salaries accepted by new engineering graduates is supplemented this year by a report from NSPE showing how the old grads are faring financially.

MONEYWISE, an engineering career (or at least the start of one) manages to hold its appeal for another year. MACHINE DESIGN's annual check of the pay picture shows starting salaries of new engineering graduates to be riding the same upward trend that we first recorded 10 years ago. The gain this year: A modest 4 per cent over 1958, or about 10 per cent better than '57.

This year may well be the lull before the storm. As we have reported in several recent issues, most authorities are convinced that a serious shortage of engineers is inevitable for the mid '60s. Salaries could begin reflecting the trend before it reaches full swing.

Data for our 1959 survey came from ten leading engineering colleges, representing a good geographical cross section of the country. The sampling, while not large, has always produced results in tune with figures based on much more elaborate studies.

Averages of starting salaries for all engineering graduates in all ten schools occurred in the range of $495 to $535; $20 higher than last year.

Again in 1959, electrical engineers took the top salaries. Averages, per college, ranged from $510 to $550. All other degrees followed reasonably close behind, in line with the over-all average, and with little significant variation.

It might be noted that this year, for the first time in our surveying history, there was an indicated demand for astronautical engineers. We aren't sure what the curriculum comprises, nor whether this is the start of a trend.

Over-all demand in '59 again placed priority on electrical engineers. Mechanical engineers were second in line by a factor of 20 per cent.

As for general recruiting activity, there were about as many company representatives on campus this year as last. All but one of our sources reports that recruiters were also more selective than last year—the great majority were interested primarily in graduates from the upper 25 per cent of the class.

Salary still is not of first concern to the graduate choosing a company. It has moved up to second place, though (from fourth last year) and follows "type of work offered." Very noticeable this year was the tendency of many graduates to choose companies that are known to sponsor study for advanced degrees.

Average Starting Salaries Reported by 10 Colleges

Curriculum	1958	1959
Aeronautical	$480-505	$485-535
Chemical	475-500	480-510
Civil	460-510	470-510
Electrical	480-535	510-550
Mechanical	465-510	490-525
Industrial	465-510	480-510
Metallurgical	465-500	475-535
Physics	470-515	500-540
All Eng.	475-515	495-535

Massachusetts Institute of Technology; Columbia University; University of Pennsylvania; Lehigh University; Case Institute of Technology; Purdue University; University of Michigan; Northwestern University; University of California, Los Angeles; Georgia Institute of Technology.

Experience Pays Off

A major salary survey just completed by NSPE gives the beginners something to shoot at.

Median income for 19,240 professional engineers (out of a membership of some 46,000) climbed to an even $10,000 in 1958—a record

This is an actual photograph of 1½" Springfield "400" hose.

NOW!

design with large diameter Teflon* hose that bends like this!

6¾"

If you design fluid handling, transfer, or hydraulic equipment, you already know Teflon hose. Wonderful! Except, up to this time larger diameters were not really flexible. But *now* look!

SPRINGFIELD "400" WITH FINGER FLEXIBILITY ONLY TITEFLEX HAS IT!**

- Minimum bend radius: *only 3⅓ times the hose diameter!* Thanks to the exclusive TITEFLEX process.
- Teflon innercore with all its properties. It's tough, lightweight, inert, resistant to corrosion and temperature extremes. Flex life is almost endless.
- Available now up to 2" in diameter, lengths to 25 feet (soon to 50!).
- Fittings prove failure-proof—right up to burst pressure of hose!
- In many cases, a shorter Springfield "400" hose can replace extruded hose at big savings.

Springfield "400" has already made exciting news in scores of applications—new uses crop up every day. How about your field? Our bulletin will set design ideas clicking. Ask your TITEFLEX distributor (see the Yellow Pages) for a copy. Or drop us a line direct.

titeflex

Do these Springfield "400" applications suggest anything to you?

TANK, CAR, BARGE, MILITARY VEHICLE application • CHEMICAL • HIGH TEMPERATURE AIR • PLASTIC COMPOUND • HOT TAR AND ASPHALT • LIVE STEAM • CORROSIVE FLUID • HIGH TEMPERATURE HYDRAULIC SYSTEMS • AIRCRAFT: high temperature fuel and lubricating systems • MISSILE: fuel and oxidizer lines of vehicles and ground support •

titeflex inc. springfield mass. PACIFIC DIVISION • SANTA MONICA • CALIFORNIA

**Teflon is a duPont trademark*
***T.M. of Titeflex, Inc., Pat. Pending*

Circle 419 on Page 19

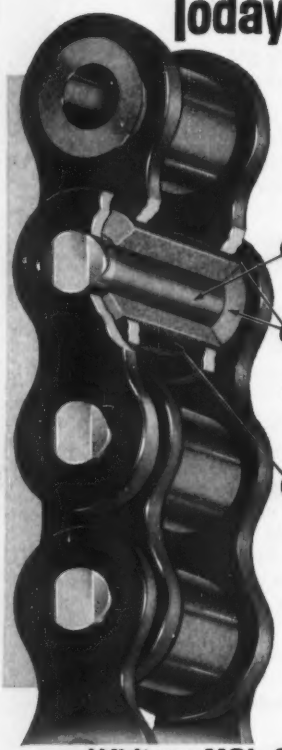
PROGRESS IN POWER TRANSMISSION CHAIN DESIGN

In 1953...

Whitney introduced the first oil-impregnated, sintered steel bushing roller chain — a major advance in chain design.

Not content with leading the field with the first sintered bushing chain, Whitney Engineers continued their exhaustive field research... carried on searching studies of the original sintered bushing chain in an effort to produce an even better chain with optimum performance characteristics. Their work, coupled with recent developments in sintering technology, resulted in the development of MSL Chain—a completely new concept in power transmission chain.

Today...



WHITNEY MSL* CHAIN . . . a product of continuing Whitney Research—is another giant step forward in chain technology because it advances and improves on the basic idea of oil-impregnated, sintered steel bushings in power transmission chain.

Only Whitney MSL Chain with oil-impregnated bushings assures complete built-in lubrication at all three critical lubrication areas:

1. **Pin**—Protective film of oil completely lubricates the live bearing area between pin and bushing, minimizing wear by reducing metal-to-metal contact.
2. **Plates**—Whitney oil-impregnated sintered steel bushings extend beyond surface of inside plates to act as lubricated thrust bearings, control clearance, and provide an oil cushion between plates, eliminating plate galling and seizing frequently caused by misalignment of sprockets.
3. **Sprocket Engagement**—MSL Chain does not require rollers, as the tough oil film on the bushing surface provides smooth sprocket engagement, cushions impact and reduces drive wear.

Inherent material characteristics of Whitney sintered steel bushings, plus bushing configuration that provides greater contact area between bushings and links, permit high interference fit, which pre-loads links and gives maximum fatigue resistance.

Whitney MSL Chain meets ASA Standards

It is made in Standard and Extended Pitch types, and is completely interchangeable with any similar pitch ASA Standard chain. For full details, write for MSL Catalog G1-59, or call your nearby Whitney Chain Distributor, who carries MSL Chain in stock for quick delivery.

***Maximum Service Life**

Advanced Design Is a Whitney Tradition

Whitney CHAIN COMPANY

A Subsidiary of Foote Bros. Gear and Machine Corporation

4567 S. WESTERN BOULEVARD
CHICAGO 9, ILLINOIS

high. A closer look at the professionals' income further discloses that:

90% earned at least	$7040
75% earned at least	$8250
50% earned at least	$10,000
25% earned at least	$13,260
10% earned at least	$19,680

Considering that over one-third of the group of survey participants are engineers with not more than ten years of experience, these figures are indeed impressive—at first glance. If you're not smart, lucky, or both, experience pays off, as these figures show:

1958 Income, According to Year of Entry Into Profession

	1947-1958	1935-1946
(Number of respondents)*	(6899)	(5253)
Lower decile	$ 6,440	$ 7,840
Lower quartile	7,310	9,210
Median	8,490	10,990
Upper quartile	9,970	14,220
Upper decile	12,280	20,170

*Data for years 1914 to 1934 were also tabulated, on basis of 6561 respondents. Lower decile for this group is $7920, median is $11,700, and upper decile is $25,930.

Other facts disclosed in the thorough NSPE study:

- Chemical engineers are the highest paid group, followed by mining and metallurgical, electrical, mechanical, and civil.
- Engineers connected with the business sector experienced smaller relative gains between 1952 and 1958 than those in other types of employment.
- While younger engineers continued to register salary increases, their gains were in line with those of the more experienced engineers, and not considerably higher, as was the case in the past.
- There appears to be a continuing trend—already apparent in 1956—toward a gradual lessening of certain types of income differentials. In particular, regional salary differences seem to be decreasing, and there also seems to be a tendency for the various fields of employment to pay similar salaries for comparable work. The gap between earnings in industry, educational institutions, and the Federal Government, for example, was narrower in 1958 than it has ever been.

Thermoelectric Air Conditioners To Be Designed for Submarines

Ocean-Water Cooled Units Will Have No Moving Parts

NEW YORK—The thermoelectric air conditioner—long an engineering speculation—is soon to become a reality. Radio Corp. of America is designing such a device under a Navy contract.

Designed specifically for a submarine, the new air conditioning equipment will handle air rejuvenation problems. Since it does not depend on compressors, motors, or other moving parts, it will generate no tell-tale noise by which the submarine could be tracked by surface craft. Other advantages reported by RCA engineers include ruggedness, maintenance-free operation, compactness and flexibility.

Based on the Peltier (thermocouple) effect, the air conditioner will depend on the cooling produced by an electric current passed through the junction of two dissimilar metals. Until the recent development of solid-state materials capable of producing temperatures sufficiently low for practical use in cooling or refrigeration, the Peltier effect was regarded as a scientific curiosity. Today it is considered entirely feasible to assemble an indefinite number of modular blocks of thermoelectric elements, whose effective cooling (or heating) capacity has been demonstrated, into an air conditioning system of virtually any size.

Heat removed from the air will be dissipated through a liquid cooling system. This presents no problem at sea, where the coolant is plentiful.

Practical realization of this type of submarine air conditioner, according to RCA, will depend almost entirely on the reduction of electrical losses and of heat flow-back. The objective is to minimize these effects while retaining the system's inherent advantages.

The system will be based on the pioneering work on thermoelectric materials and devices done at RCA's David Sarnoff Research Center at Princeton, N. J.

Because of the many advantages, the Navy foresees ultimate use of thermoelectric air conditioners on all vessels, including submarines.

FOR HIGH SPEED FABRICATION

NEW INSUROK®

Free-Machining, Laminated, Rolled Tubes Meet Mil-P-79B and Federal L-L-3

INSUROK GRADE	NEMA GRADE	MILITARY SPECIFICATIONS	FEDERAL SPECIFICATIONS
T-300	X	Mil-P-79B, Type PBM, Form TR	L-L-31, Type 1, Grade X
T-301	XX	Mil-P-79B, Type PBG, Form TR	L-L-31, Type 1, Grade XX

T-300 and T-301—two new, improved grades of INSUROK paper base, laminated tubes are distinguished by their excellent FREE MACHINING characteristics. They do not chip or delaminate when fabricated. Having good dielectric properties and uniform appearance, these light colored INSUROK tubes are suited to any fabricating operation. You can machine INSUROK T-300 and T-301 at top operating speeds.

For your electrical and mechanical applications you are offered a wide choice of tube sizes in these new grades:

• Inside diameters up to 12 inches • Wall thicknesses up to 2 inches

CHARACTERISTIC PROPERTY COMPARISON

CHARACTERISTIC PROPERTIES	NEMA XX REQUIREMENTS	T-301 TYPICAL VALUES
	Test Samples From 1" x 1¼" Tubes	
Water Absorption	2% maximum	1%
Density (grams per CM^3)	1.12 minimum	1.25
Dielectric Strength (perpendicular to laminations)	290 volts/mil. minimum	400 volts/mil.

Richardson offers a complete line of INSUROK laminated grades in sheets, rods and tubes . . . also provides complete fabrication service at its Melrose Park, Illinois and New Brunswick, New Jersey plants.

For full information on INSUROK T-300 and T-301, write direct or contact sales offices in principal cities.

the RICHARDSON COMPANY

LAMINATED AND MOLDED PLASTICS Founded 1858

2795 LAKE STREET • MELROSE PARK, ILLINOIS • SALES OFFICES IN PRINCIPAL CITIES

Circle 421 on Page 19

Now available on all Parker-Hannifin

STRAIGHT THREADS FOR LEAK-PROOF

Industry's new standard as published in J. I. C. Recommendations (April, 1959) and S. A. E. Standards (1959 Handbook)

Why accept less?

Parker-Hannifin now offers a new standard *at no extra charge*—high-pressure hydraulic components with straight thread port connections* for O-ring type fittings. This new standard—assuring a leak-proof and drip-free seal—is the most logical engineering approach to the problem of hydraulic circuit connections. The Joint Industry Conference Recommendations now state:

"Fittings that incorporate separate synthetic or metal-to-metal seals, or seals that seal with pressure *should* be equipped with Unified National Fine (UNF) straight thread port connections."

And the Society of Automotive Engineers' 1959 Handbook states:

"The S.A.E. straight thread 'O'-ring boss is the preferred port for use in hydraulic devices."

Both support this new standard—and the U. S. Navy Bureau of Ships in MS16142 (SHIPS) has adopted the S.A.E. Straight Thread Boss Design as their straight thread standard for use in hydraulic and air systems in Naval ships. Such extensive support is understandable. The Parker-Hannifin straight thread port connections combine a built-in pressure sealing device with a rigid mechanical connection. This contrasts with the loose connection of a "backed-off" pipe thread and a relatively weak auxiliary sealing device.

Straight thread fittings and port connections are not a proprietary product or design. Although developed by Parker-Hannifin, they were immediately made available to the fluid power industry on a completely open basis.

They have been thoroughly field tested. In the severe service on mobile hydraulic equipment, today more than 6 out of 10 of the port connections are of the straight-thread type.

Now machinery builders and users alike are turning to this proved method of port sealing. Pipe threads for high-pressure hydraulic applications are fast becoming obsolete as more and more leading manufacturers recognize these advantages of straight threads in their production equipment:

No more wedging action with resulting distortion and breakage due to over-tightening . . .

No more messy pipe dope and the danger that it will infiltrate the hydraulic system . . .

No more leaks because of temperature changes or high shock conditions . . .

No more failures of costly auxiliary seals due to weak, imperfect threads that fit on thread run-out.

Why accept less? Next time you order high-pressure hydraulic components, specify Parker-Hannifin with straight thread port connections and fittings . . . you'll get leak-proof sealing—industry's recommended standard.

**Mobile equipment spool type control valves are all supplied with straight threads. Other components are still available with dry-seal pipe threads.*

HANNIFIN COMPANY
545 S. Wolf Road, Des Plaines, Illinois

Parker FITTINGS AND HOSE DIVISION
17325 Euclid Avenue, Cleveland 12, Ohio

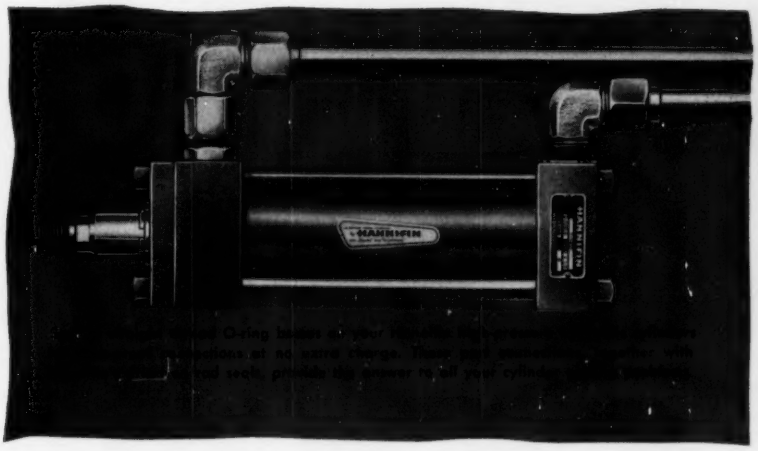
Parker SEAL COMPANY
10567 Jefferson Blvd., Culver City, California

Parker HYDRAULICS DIVISION
17325 Euclid Avenue, Cleveland 12, Ohio

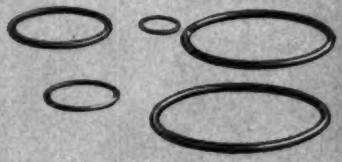
4 DIVISIONS OF PARKER-HANNIFIN CORPORATION

high-pressure hydraulic components

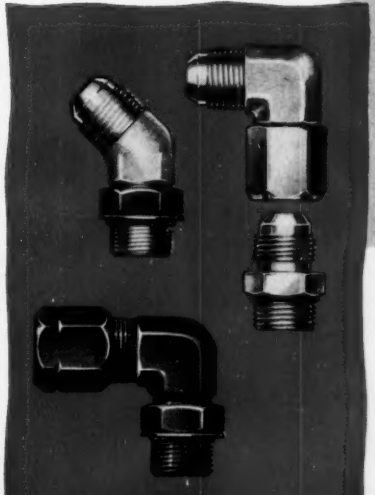
PORT CONNECTIONS...



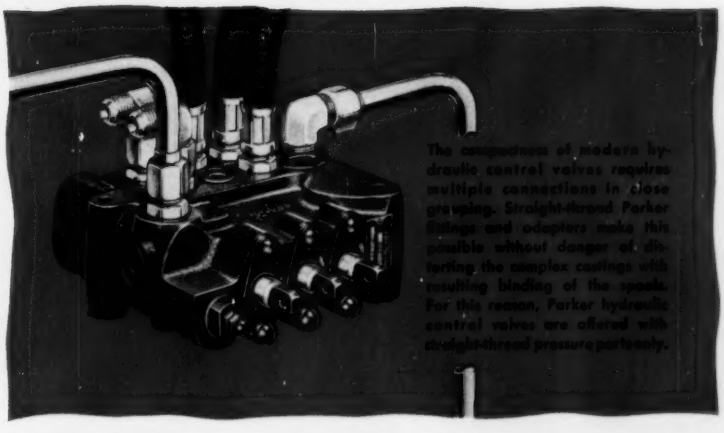
Both Parker's new "Krimp-lok" permanent-end hose assemblies and "Hose-lok" reusable fittings (as well as all adapters) are available with straight threads, O-ring sealed for any specified fluid.



The O-rings used in Parker port connections are made only from service-tested Parker Seal Company compounds. With an ever-increasing number of fire-resistant fluids now on the market, it pays to avoid "jack-of-all-fluids" seals and stay with the Parker Seal compound specifically made for the fluid you will be using.



There's a complete line of Parker straight thread O-ring fittings and adapters for you to choose from . . . Triple-lok (flare type) and Ferulok® (flareless, bite-type). Either method assures you leak-proof, trouble-free hydraulic connections.



The compactness of modern hydraulic control valves requires multiple connections in close grouping. Straight-thread Parker fittings and adapters make this possible without danger of distorting the complex castings with resulting binding of the spools. For this reason, Parker hydraulic control valves are offered with straight-thread pressure portsonly.

IN A SQUEEZE?

HERE'S YOUR ANSWER
FOR PRECISION TUBING AT REGULAR TUBE PRICES

Quality specifications and profit margins have you in a squeeze on tubing? Precision Tubing assures you unsurpassed quality of temper, straightness, accuracy, finish and roundness at regular mill prices . . . and test results prove it.

Whatever the type of alloy tubing you need from .010" to 1.125" O.D. in copper, brass, aluminum, up to ⅝" O.D. in nickel and nickel alloys, Ni-Span "C", phosphor-bronze and nickel silver Precision can supply it. Whether you need Bourdon, round, rectangular, oval or square . . . preformed to special shapes . . . or Coaxitube-Precision can supply it to your specifications.

For improved quality at lower costs specify Precision Tubing. Write for technical data to Dept. 10, Precision Tube Company, Inc., North Wales, Pa.

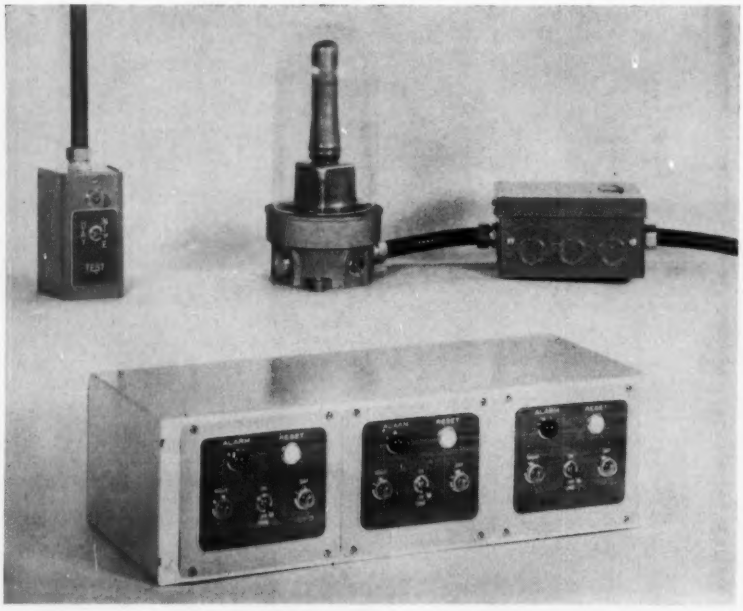
GET THIS NEW TUBING DATA CATALOG . . . FREE!

PRECISION TUBE COMPANY

Circle 422 on Page 19

First Air-Launching of Corvus Successful

First test-firing of Navy's Corvus is heralded as extremely successful by Temco Aircraft Corp., Dallas, prime contractor for the missile. A highly successful flight was "almost guaranteed," a company spokesman reports, because of extensive proving of components during ground testing. All conditions the missile was expected to encounter were simulated in the ground test program, including temperature variations, vibration, shock, and environmental problems. Corvus is a supersonic missile using a prepackaged liquid rocket engine. It is intended as an air-to-ground missile for use by carrier-based aircraft when attacking heavily defended surface ships or land bases. It is currently being tested at the Navy's Pacific Missile Range Test Center, where first firing was from an A4D Skyhawk.



Standing Waves Warn of Intruders

Radar-like device small enough to fit into a briefcase has a range of several thousand feet and can't be jammed by countermeasures. Standing Wave Area Motion Indicator (SWAMI) is an intruder detector that saturates an area with ultra-high-frequency radio waves. The sensor (rear, right) is a high frequency, low power radio transponder. It responds to intruder disturbance of the controlled radio-frequency field pattern and transmits a signal to a control box nearby. The system is sensitive to willful tampering, line failure, critical component failure, or power failure during day operations. Switched to night operation, it provides maximum security against movement within the area under surveillance. U. S. and Canadian rights are held by Singer Mfg. Co., New York.

SEE MORE AT
WESCON BOOTHS
3324-3326

Snap-in spring-loaded contacts for quick-disconnect or permanent connection. Modules—2 or 4 tier—snap together or apart for extreme flexibility. Contacts are solderless crimp-type. Up to 30 modules per foot of track.

MODULOK
TERMINAL BLOCKS

with solderless contacts and interchangeable modules

Same flexibility as regular MODULOK. Completely crimped contacts. Snap-in to insert. Press spring-loaded latch to release. Up to 30 modules (90 coax connections) per foot of track.

BURNDY

59-12

OMATON DIVISION **BURNDY** NORWALK, CONNECT.; IN EUROPE: ANTWERP, BELGIUM; TORONTO, CANADA

Circle 423 on Page 19

Metal Tube Collapses for Shipment, Is Inflated On-the-Job

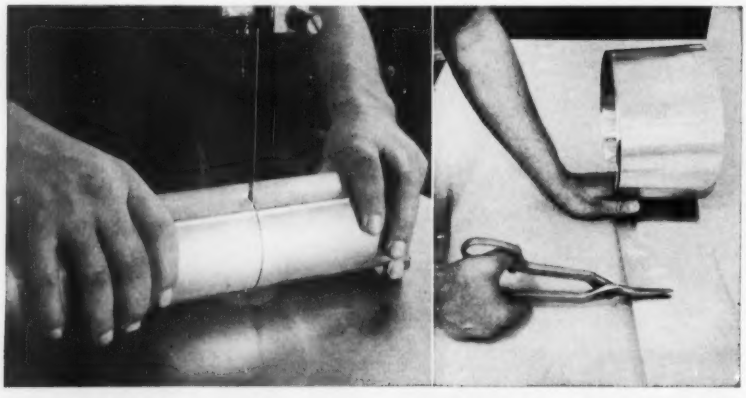
Base tube . . . . . is rolled flat . . . . . and reinflated by air or water pressure

ALLEN PARK, MICH. — Light-wall seamless metal tubing that can be flattened into ribbon form has been developed by Calumet & Hecla Inc., and will be produced starting this fall. Because the new tube can be easily inflated in the field, and because of space savings during both storing and shipping, major innovations in tube-using industries are predicted by D. W. Blend, general manager of C & H's Wolverine Tube Div.

Field inflatability of tubing might make it possible, for example, to ship the entire ductwork for the heating system of a seven-room house in an orange crate, rather than in trailer-truck loads. The Strubing, i.e., strip tubing, ribbon might be strung through the house and then inflated right in place—for a major saving in time and effort over conventional installation of ductwork. Other potential uses include lining-by-inflation to construct low-cost corrosion-resistant piping or processing vessels and to repair sewers and water mains. Large diam tube may even become a practical light-wall rocket or missile body if the tubing is made from one of the so-called exotic metals.

Inflation of Strubing will vary with the application. The company's engineers have used air pressure, hydraulic pressure, and mechanical means to inflate it. The thinner wall thickness samples have even been inflated by using tap-water pressure.

Inherent in the product produced by the rolling process is a pair of fins on the outside. These fins provide added stiffness to thin-walled tube. If undesirable in a particular job, they will be removed as the tubing is formed.

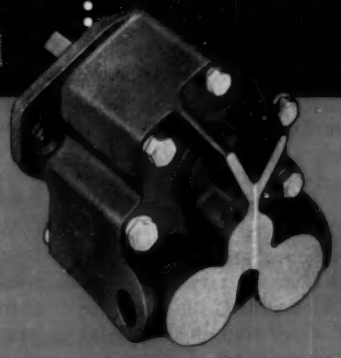


Once inflated, tubing can be cut by any conventional means, as evidenced by the 3-in. diam tube cut on a band saw, left. Cutting off lengths before inflation, right, is especially convenient when varying lengths are needed for different jobs on a day-to-day basis.

Strubing can be made as small as the lead in a pencil. At left is the starting base tube, at right, the final Strubing, and in the center the inflated Strubing. It can also be made in pipe sizes large enough for a man to walk through. Wall thickness can be varied from as thin as household metal foil to as thick as conventional pipe.

DYNAMIC DIFFERENCE

in hydraulic performance



Webster

POSITIVE DISPLACEMENT GEAR-TYPE PUMPS

Things have changed on the golf course . . . the old converted Model A has been replaced by more efficient, specialty equipment. Like this Worthington mowing rig. It has front wheel drive, rear wheel steering and gang mowers that raise and lower hydraulically.

A fast-acting Webster hydraulic pump supplies a dependable flow of fluid power for this versatile application. For this same reason, Websters are used on all types of construction, maintenance, agricultural and industrial equipment. More, Webster Gear-Type Pumps are compact — adapt easily and economically to the job and your product.

Hydraulics in your design? Keep Webster in mind *for the dynamic difference that pays!*

HCS SERIES POSITIVE DISPLACEMENT GEAR-TYPE PUMP

Shaft seal: lip type
Drive: direct, gear or belt
Capacity: 5 sizes, 5 - 17 gpm
Pressure: to 1500 psi
Operating speeds: to 2400 rpm (1800 rpm max. on 4XCS)
Porting: side (Std.) end (Opt.)
Valve: optional; internal relief, adjustable 800 - 1500 psi

BULLETIN HY1 gives complete engineering characteristics — performance and installation data.

Call the man from Webster

. . . he's one of a staff of engineers specially trained in hydraulic application. He can help you solve special problems when hydraulics become a part of your design.

Photo from Worthington Mower Company, Stroudsburg, Pa., a subsidiary of Jacobsen Manufacturing Co., Racine, Wis.

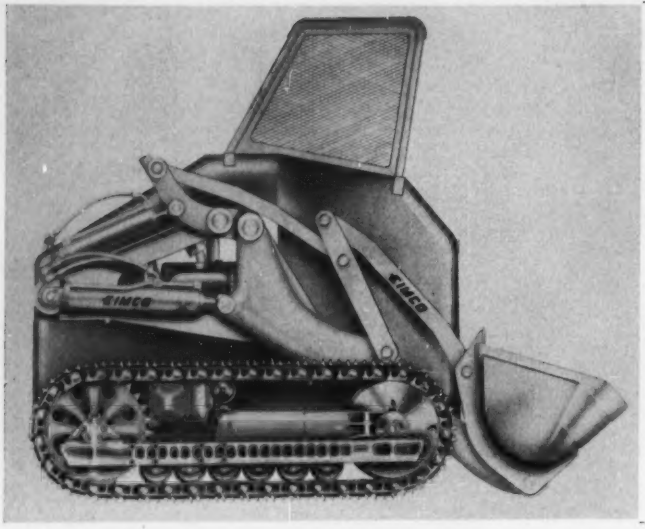
OIL HYDRAULICS DIVISION

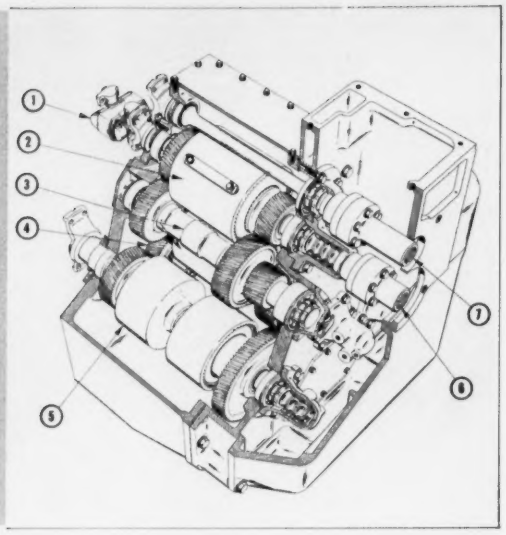
WEBSTER ELECTRIC

our 50 *th year* **RACINE · WIS**

Franklin adv. H-118

Circle 424 on Page 19





Compact Crawler

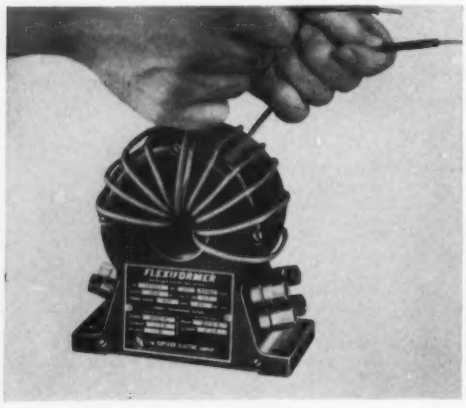
Capacity for 33,000-lb drawbar pull, given perfect traction, is claimed for this scaled-down version of Emico's 105 series tracked vehicle. The smaller model claims improvements like functional stress-flow design of structural members, separate mounting of radiator and fan for maximum cooling capacity, and gear housing cast in one unit for minimum bolted assembly and maximum strength and rigidity. Incorporated in the 100-hp model, designated the 103, are such proven features of the 105 as central mounting of the driver for better visibility, and Unidrive transmission with gears that never reverse rotation and need no master clutch even to shift from full forward to full reverse. High efficiency torque converter coupled with this transmission allows Emico 103 to climb 90 per cent grades in either forward or reverse. Cutaway sketch shows input coupling assembly from the torque converter (1), input shaft (2), intermediate shafts (3), reverse idler (4), output shafts with counter-rotating gears (5), and power take-offs (6 and 7).

Packaged-Primary Transformer Gives Tailored Turn Ratios

BRISTOL, CONN.—Searching through lab shelves for a transformer with just the right ratio may soon be outdated. Superior Electric Co. has developed a versatile new "do-it-yourself" packaged primary that makes stocking of many fixed-ratio transformers unnecessary.

Called Flexiformer, the unit is essentially a self-contained toroidal primary coil made up of 400 turns of 24-gage copper wire wound on a silicon-steel core. The experimenter desiring a certain ac output voltage (input is 120 v, 50/60 cps) merely hand threads the proper number of secondary turns through the toroid opening. Input voltage can be modulated with a variable transformer.

When used as a current transformer, the packaged Flexiformer winding becomes the secondary; current is inducted by a straight wire that passes through the center of the opening in the toroid.



Correct number of turns wound on the Flexiformer packaged primary is determined by dividing the desired output voltage (plus approximately 25 per cent for internal transformer drop) by 0.3—the volt/turn ratio. Wire size depends on the secondary current.

Meetings and Shows

Aug. 31-Sept. 2—

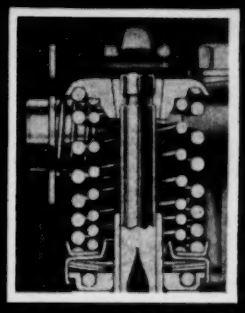
Army-Navy Instrumentation Program Symposium and Industry Briefing to be held at the Statler Hilton Hotel, Dallas. Further information can be obtained from G. Jackson Butterbaugh, Asst. Director of Public Relations, Bell Helicopter Corp., P. O. Box 482, Fort Worth 1, Tex.

Sept. 1-3—

Association for Computing Machinery. 14th National Conference to be held at Massachusetts Institute of Technology, Cambridge, Mass. Additional information is available from Dr. Frank M. Verzuh, Computation Center, MIT, Cambridge, Mass.

Sept. 6-12—

International Conference for Standards on a Common Language for Machine Searching and Translation to be held at the Tudor Arms Hotel,



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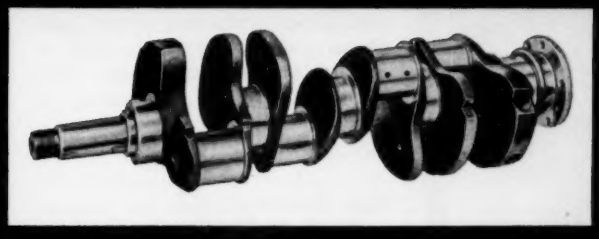

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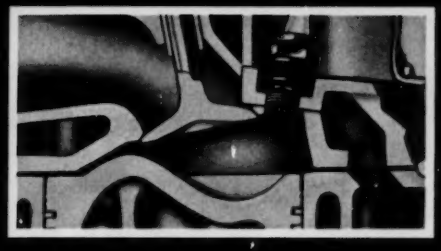

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Circle 425 on Page 19

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MODEL	UV-549	UV-461	UV-401
Eng. Max. Hp. (gaso.)	257 @ 3400 rpm	226 @ 3600 rpm	206 @ 3600 rpm
Power Unit Net hp:			
gaso	208 @ 2600 rpm	170 @ 2600 rpm	160 @ 2800 rpm
LPG	201 @ 2600 rpm	166 @ 2600 rpm	155 @ 2800 rpm
nat. gas	178 @ 2600 rpm	153 @ 2600 rpm	132 @ 2800 rpm
Bore and Stroke	4½ x 4¼	4⅛ x 4¼	4⅛ x 3¾
Displacement cu in.	549	461	401

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Cleveland. Sponsors are Western Reserve University and Rand Development Corp. Further information can be obtained from Secretariat: Center for Documentation and Communication Research, Western Reserve University, Cleveland 6, Ohio.

Sept. 7-11—

Illuminating Engineering Society. Annual National Conference to be held at the Fairmont and Mark Hopkins Hotels, San Francisco. Futher information can be obtained from IES headquarters, 1860 Broadway, New York 23, N.Y.

Sept. 14-17—

Society of Automotive Engineers Inc. National Farm, Construction, and Industrial Machinery Meeting (including production forum and engineering display) to be held at the Milwaukee Auditorium, Milwaukee. Further information is available from SAE, 485 Lexington Ave., New York 17, N. Y.

Sept. 16-17—

American Die Casting Institute. Annual Meeting of the Institute and its research arm, the Die Casting Research Foundation, to be held at the Edgewater Beach Hotel, Chicago. Additional information is available from institute headquarters, 366 Madison Ave., New York 17, N. Y.

Sept. 17-18—

American Society of Mechanical Engineers—American Institute of Electrical Engineers. Engineering Management Conference to be held at the Statler Hilton Hotel, Los Angeles. Additional information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 20-23—

American Society of Mechanical Engineers. Petroleum Mechanical Engineering Conference to be held at the Rice Hotel, Houston. Further information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 20-25—

Instrument Society of America. Instrument-Automation Conference

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and Exhibit to be held at the Palmer House and the International Amphitheatre, Chicago. Additional information can be obtained from ISA headquarters, 313 Sixth Ave., Pittsburgh 22, Pa.

Sept. 21-22—

Steel Founders' Society of America. 57th Fall Meeting to be held at the Homestead, Hot Springs, Va. Additional information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

Sept. 21-22—

Standards Engineers Society. Eighth Annual Meeting to be held at the Somerset Hotel, Boston. Additional information can be obtained from Charles T. Ajamian, P. O. Box 538, Wayland, Mass.

Sept. 23-25—

American Institute of Electrical Engineers—Institute of Radio Engineers. Nonlinear Magnetics and Magnetic Amplifiers Conference to be held at the Shoreham Hotel, Washington, D. C. Further information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Sept. 24-26—

Porcelain Enamel Institute. Annual Meeting to be held at the Greenbrier, White Sulphur Springs, W. Va. Further information is available from PEI headquarters, Associations Bldg., 1145 Nineteenth St. N.W., Washington, D. C.

Sept. 28-Oct. 1—

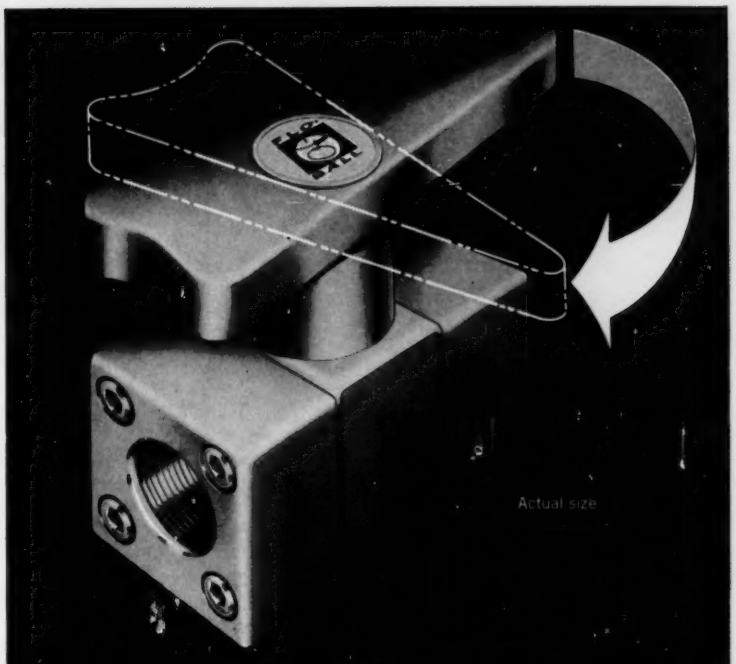
American Welding Society. Fall Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Further information is available from society headquarters, 33 W. 39th St., New York 18, N. Y.

Sept. 28-Oct. 1—

Association of Iron and Steel Engineers. Convention to be held at the Sherman Hotel, Chicago. Additional information is available from AISE headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

Sept. 28-Oct. 1—

American Society of Mechanical Engineers — American Institute of Electrical Engineers. National Pow-



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Circle 427 on Page 19

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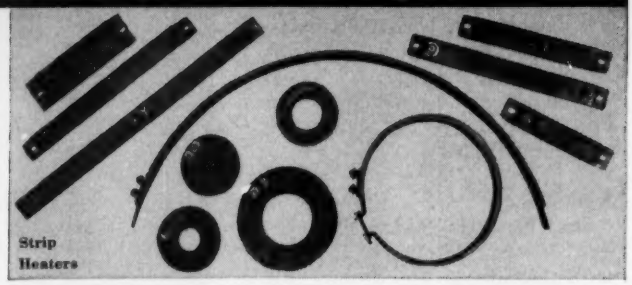

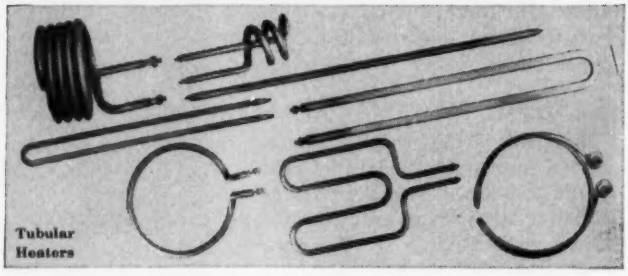

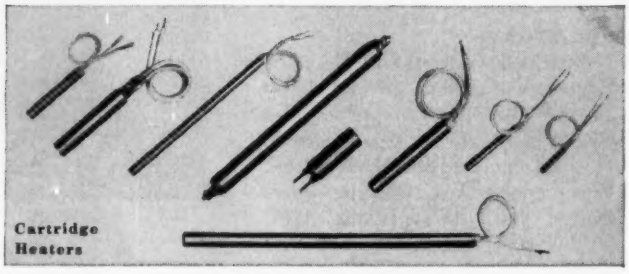

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Our new Catalog 60 provides detailed product information and suggests numerous applications for the complete line of Chromalox electric heaters for industry. If you have not yet received a copy, please let us know.

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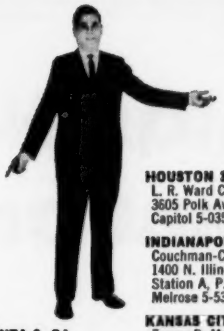

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er Conference to be held at the Muehlebach Hotel, Kansas City, Mo. Additional information can be obtained from Meetings Dept., ASME, 29 W.39th St., New York 18, N. Y.

Sept. 30-Oct. 1—

Institute of Radio Engineers — American Institute of Electrical Engineers. Industrial Electronics Conference to be held at the Mellon Institute, Pittsburgh. Further information can be obtained from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

Oct. 5-9—

Audio Engineering Society. Annual Convention and Professional Equipment Exhibit to be held at the Hotel New Yorker, New York. Further information is available from Harvey Associates, 580 Fifth Ave., New York 36, N. Y.

Oct. 5-10—

Society of Automotive Engineers Inc. National Aeronautic Meeting, including manufacturing forum and engineering display, to be held at The Ambassador, Los Angeles. Further information is available from SAE, 485 Lexington Ave., New York 17, N. Y.

Oct. 7-9—

Industrial Designers Institute. Second Annual Ideas in Design Materials Show to be held at the Commodore Hotel, New York. Additional information is available from Leonard S. Rogers, 19 W. 44th St., New York, N. Y.

Oct. 7-9—

American Vacuum Society Inc. 1959 National Symposium on Vacuum Technology to be held at the Sheraton Hotel, Philadelphia. Additional information can be obtained from society headquarters, P. O. Box 1282, Boston 9, Mass.

Oct. 8-10—

American Society of Tool Engineers. Semiannual Meeting to be held at the Chase-Park Plaza Hotels, St. Louis. Further information is available from ASTE, 10700 Puritan Ave., Detroit 38, Mich.

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in Viton A, Vyram, Polyurethane, and other unusual elastomeric materials having excellent resistance to many petroleum oils, synthetic lubricants, fuels, phosphate and silicate ester fluids—in a temperature range of —40° to + 500°F.

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Circle 430 on Page 19

electric motion control facts

for IDEA MEN

240 fast-cycling Warner electric clutches control yarn feed on carpet tufting machine

Warner SF-250 electric clutches in yarn feed drive produce textured effect in loop carpeting. Millisecond operation of the clutches contributes much to the speed required when tufting at 550 to 720 stitches per minute.

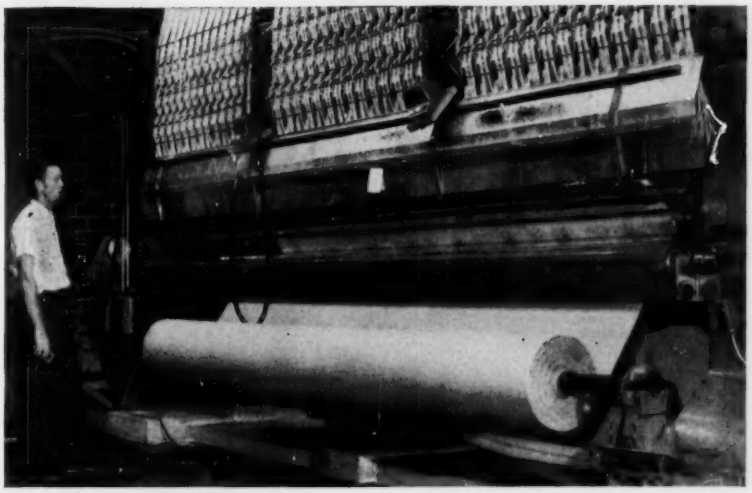
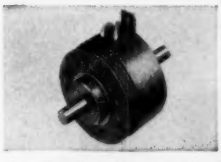


Fig. 2—Automatic carpet tufting machine—showing at top of illustration are the feed rolls controlled by the Warner stationary field electric clutches.

Pattern is template controlled

In tufting, the needles sew yarn in loops through a backing material as it passes through the tufting machine (Fig. 2). Variation in the height of the yarn loops produces the sculptured effect. Loop height is controlled by increasing or decreasing the speed of the rollers feeding yarn to the needles. Speed of each roller is controlled by two Warner SF-250 clutches—one for high-speed drive, the other for low. A chain drive (Fig. 1) transmits power to the clutches. The "master mind" behind the clutches is a rotating drum with the carpet pattern cut into the drum's surface (Fig. 3). Sensing fingers (one for each clutch) feel the braille-like rug pattern, triggering a relay in the control system and switching automatically from one clutch to the other. All in all, it's a simple, accurate, foolproof system—a good example of versatile control made possible by Warner electric clutches (and brakes).



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You have only to consider the three big advantages of electric motion control to see why Warner electric brakes and clutches are ideally suited to this and any other highly controlled apparatus.

First—instantaneous engagement and release permit ultra-fast cycling.

Second—clutches operate directly from actuating current, provide a packaged plug-in drive without solenoids, rigid piping, or complex mechanical linkages. They make power drives compact, self-contained units.

Third—stepless torque modulation through a potentiometer insures velvet-soft engagement. Torque in the first few seconds of clutch engagement is adjustable through its full range, protecting delicate equipment or material—yet bringing drives quickly to full speed.

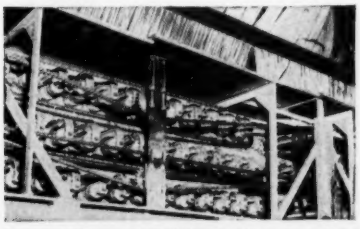

Fig. 1—Warner SF-250 clutches and chain drives link yarn feed rolls to the main drive. More than 100 pairs of electric clutches are used in this pattern attachment drive.

Fig. 3.—Contact fingers riding against the drum actuate relays in the clutch circuit, varying the amount of yarn going to each needle.

WARNER

Originators of electric motion control

Warner Electric Brake & Clutch Co.

Beloit, Wisconsin

Please send complete information about Warner Electric Brakes and Clutches.

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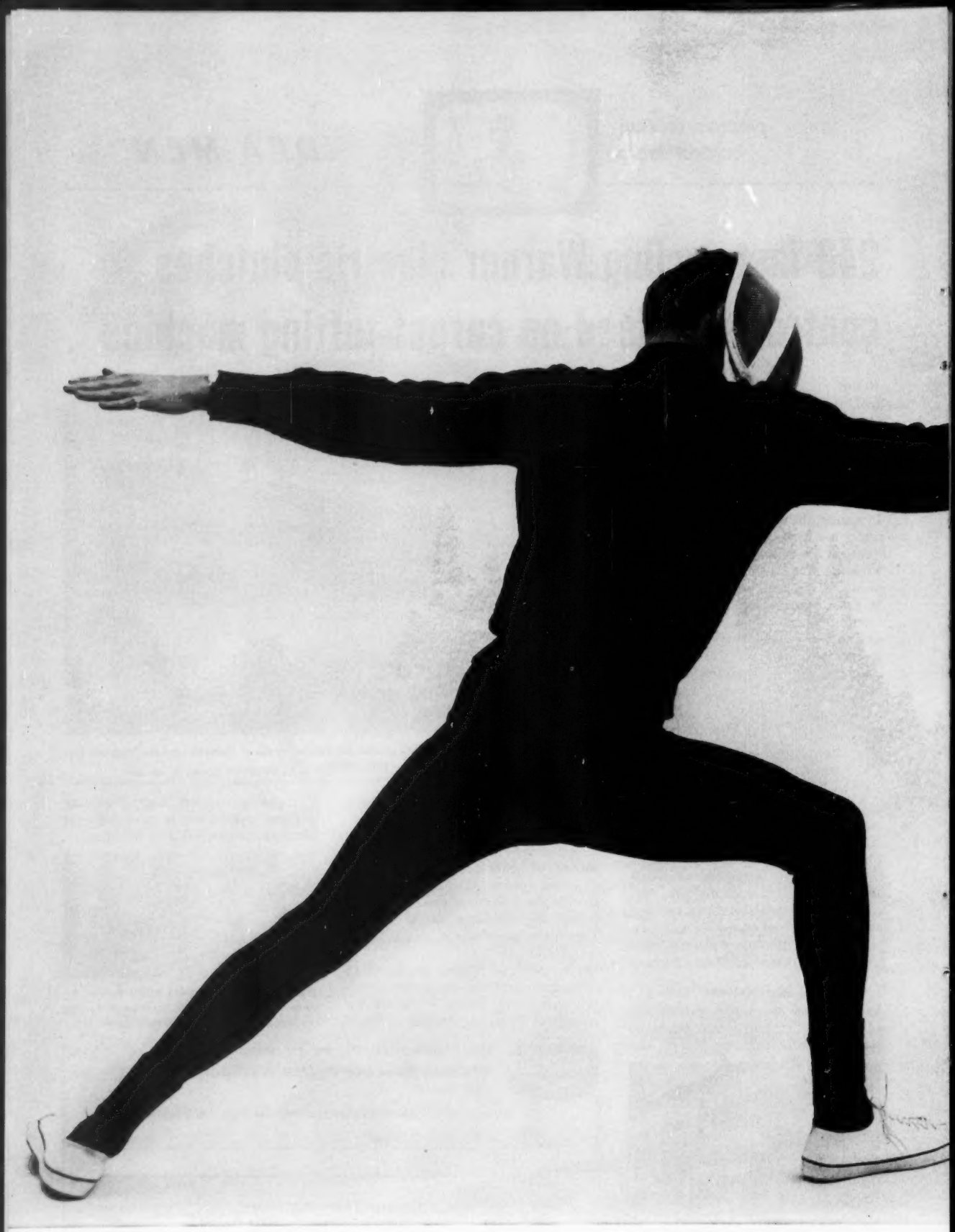

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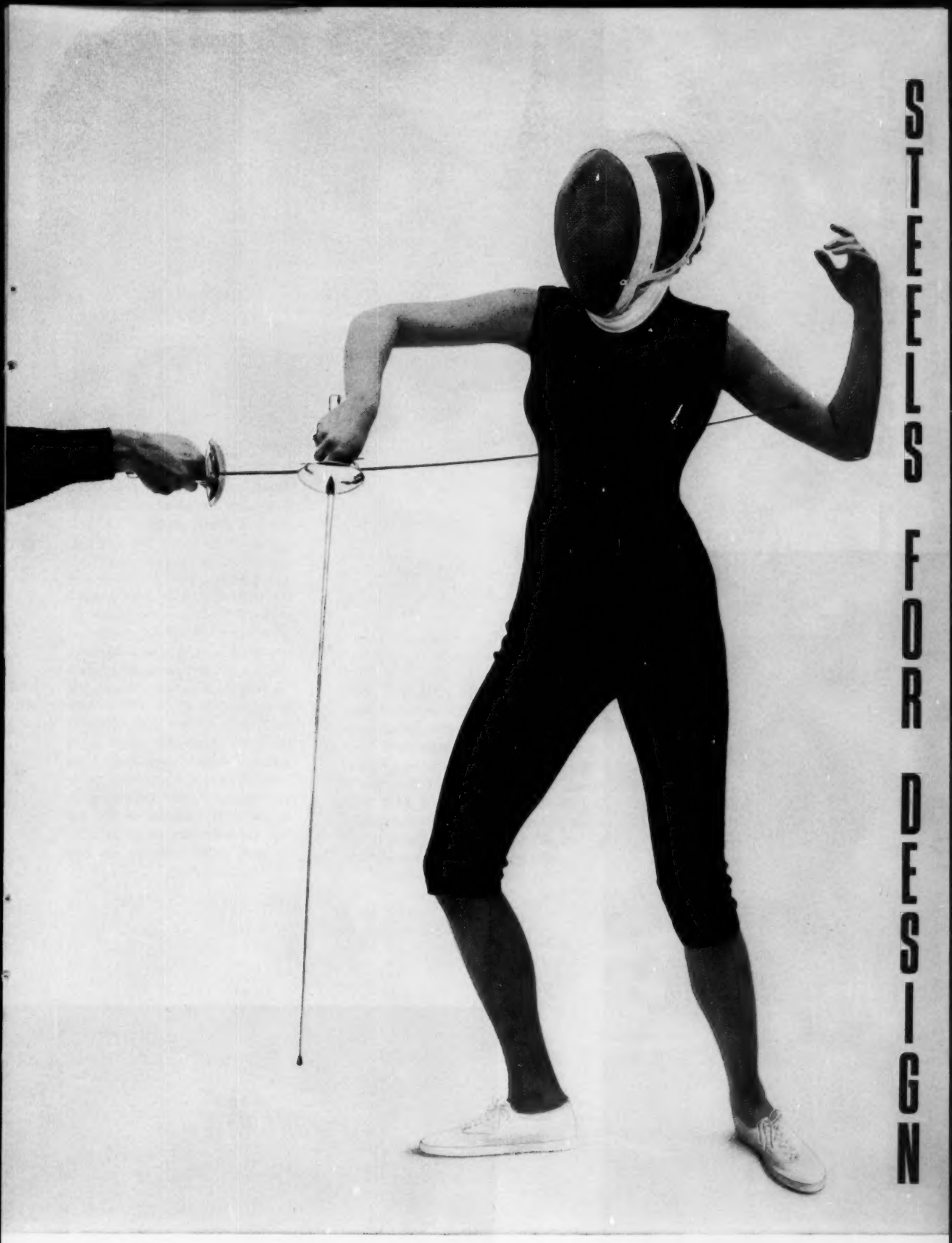

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your blade. It had to be as light as human ingenuity could make it. But it also had to be strong,

made steel the most important metal in the history of man. For some modern, lightweight examples, turn the page ▷ ▷ ▷

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Stainless Steel builds a stronger, lighter trailer. This 40-foot trailer is one of the latest models designed and built by the Fruehauf Trailer Company. It's the strongest, lightest trailer in its class because it was built with Stainless Steel. The Stainless has a yield point of 120,000 psi, almost four times greater than competitive materials, so the walls, roof, and braces could be made thin and very light, yet they are rigid and strong. The exceptional corrosion resistance of Stainless Steel practically eliminates maintenance. This trailer will never have to be painted or refinished and it will still look clean and new after many thousands of miles.

High Strength Steel cuts cable reel weight 25%. The George Evans Corporation is the largest manufacturer of cable reels in the United States. Each of these reels has to carry and protect about $5000 worth of cable—seven tons of it. The reel must be strong and rugged or it will buckle under its load as it bumps over rocks and timbers in the field. It must *also* be exceptionally light, or freight costs will be exorbitant and field handling almost impossible. For a long time, these reels were made of wood and they lasted about two years. Then, the company started to make an all-steel reel, with the rims made of USS COR-TEN High-Strength Low-Alloy Steel. The COR-TEN Steel reels are much stronger and they weigh 25% less than wooden reels. They *cost less*, too, because they cut freight charges; they practically eliminate maintenance; and they will last about twenty years.

USS "T-1" Alloy Steel cuts tanker weight, increases payload. Trinity Steel Company of Dallas, Texas, makes LPG transport tankers and recently the company tripled production to meet the demand for its new, lightweight models. Trinity increased the payload of these tankers substantially by cutting the weight of the carrier itself as much as one-third. They used USS "T-1" Constructional Alloy Steel. Because "T-1" Steel is extremely strong—100,000 psi minimum yield strength—the tank walls are made about ⅓ thinner—with a comparable reduction in weight. And the weldability of "T-1" Steel meets the rigid ASME code that requires X-Ray and magnetic particle inspection of all joints.

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United States Steel USS

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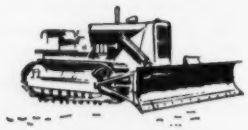
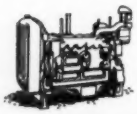


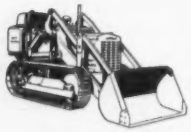
Challenging Engineering Opportunities at CATERPILLAR

be a part of the company building the world's most complete line of earthmoving equipment

Find the satisfaction of *growth* and *stability* within a *growth* company – where imaginative men are creating products for highway construction – industry – farms – national defense – products which build a better world.



Caterpillar offers top ranking Research and Development opportunities – stimulating assignments – professional and personal advancement. You'll associate with the leaders and pioneers in this field – and have at your command the finest equipment, laboratories and development facilities. Please write us, telling all about yourself. Inquiries are confidential, of course.



(Below – New Caterpillar Technical Center presently under construction)

responsible positions available in
RESEARCH — DESIGN DEVELOPMENT

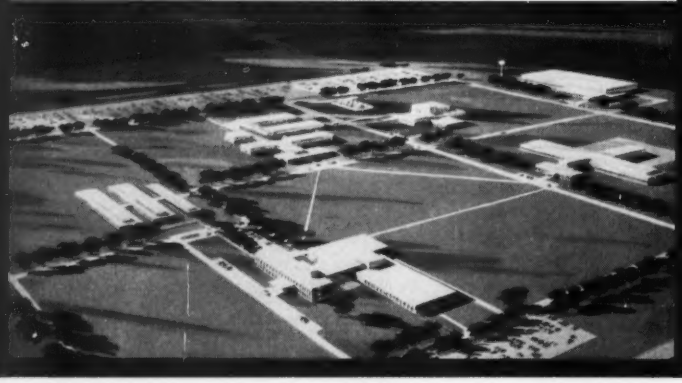
GAS TURBINE LABORATORY
Design, ignition, fuel and combustion systems, etc.

ENGINE DEVELOPMENT LABORATORY
Fuel injection, turbocharged engines, combustion, etc.

VEHICLE COMPONENTS LABORATORY
New power shift transmissions, transmissions, controls, clutches, final drives.

VEHICLE DEVELOPMENT LABORATORY
Quantitative and comparative performance evaluation, soil mechanics, full scale load analysis.

PRODUCT AND APPLICATION ENGINEERING DESIGN
Engines, systems, fuel injection, tractor, transmission, vehicle configuration, earthmoving machinery.



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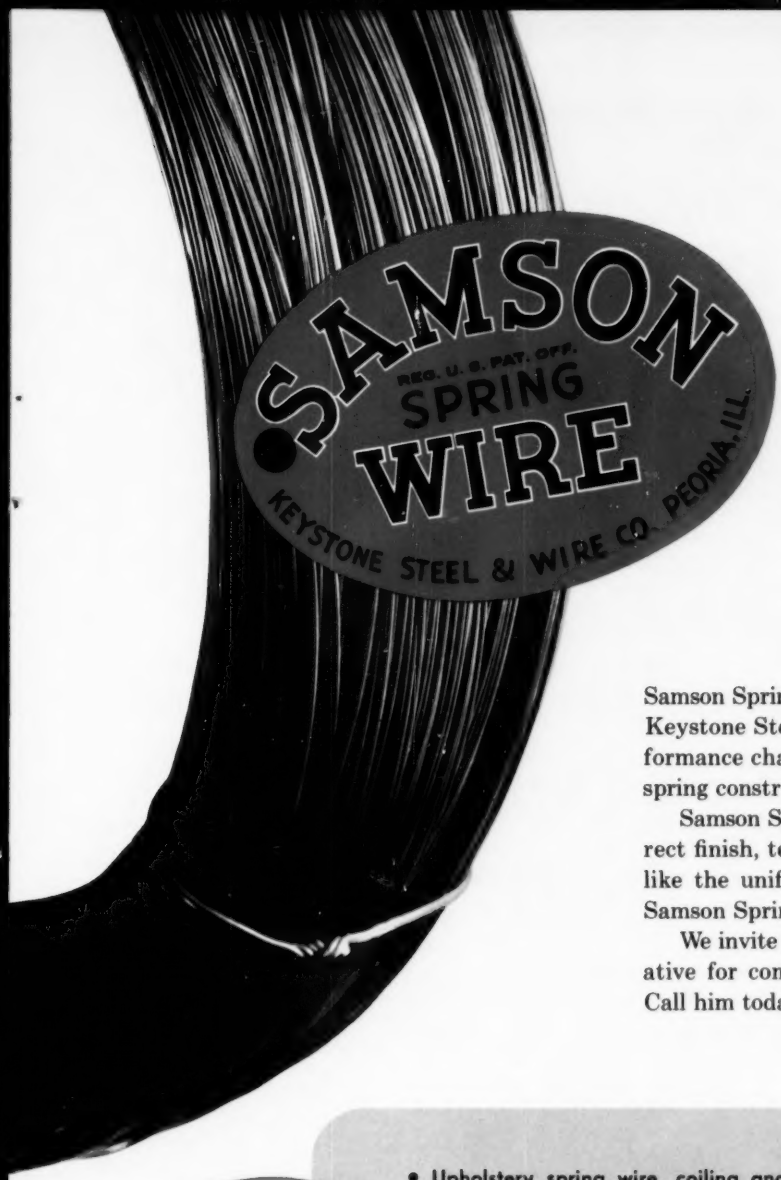
Professional and Technical Employment

CATERPILLAR TRACTOR CO.

PEORIA, ILLINOIS

Circle 432 on Page 19

Circle 433 on Page 19→



. . . meets every spring construction requirement

Samson Spring Wire—an up-to-the-minute product of Keystone Steel & Wire Company, with modern performance characteristics—is available to fulfill every spring construction.

Samson Spring Wire is custom made with the correct finish, temper and tensile to fit each use. Users like the uniform size and coiling characteristics of Samson Spring Wire.

We invite you to contact your Keystone representative for complete details on Samson Spring Wire. Call him today—or write direct.

name your need . . .

- Upholstery spring wire, coiling and knotting quality
- Upholstery spring wire for marshall pack units
- Special upholstery spring wire for use in automatic coiling and knotting machines
- Common lacing wire
- Special automatic lacing wire
- Spring wire for cross helical springs and for short tension springs
- High carbon wire for borders and braces
- High carbon wire for cold rolling into border and brace sections
- Wire for severe crimping or clinching upholstery spring construction

Keystone Steel & Wire Company
Peoria 7, Illinois

KEYSTONE
WIRE FOR INDUSTRY

What's more important to you

QDP or PDQ?*

Whirlpool Corporation reports: among 598, 265 components supplied by Amplex the first 4 months of 1959, there were only 5 rejects!

Quality, Delivery, Price...
this Amplex philosophy enables our customers to cut their production and warranty costs.

The "Price" vendor with poor quality will increase your costs.

Amplex prices are low but cost-saving quality always comes first. A quality record of 99.999992% is the reason why Whirlpool Corporation says, "Quality is our business, too. That's why we purchase components from Amplex."

Contact your local Oilite® representative today. Reduce your costs with quality-controlled Oilite Precision Parts and Bearings. See "Bearings" in the Yellow Pages or write to Dept. S-8.

* *Quality-Delivery-Price vs. Price-Delivery-Quality*

® Only Chrysler makes Oilite

SINCE 1929 — A CHRYSLER PRODUCT — OILITE

the most trusted name in powder metallurgy!

AMPLEX DIVISION
CHRYSLER CORPORATION, DETROIT 31, MICHIGAN
PRECISION PARTS • SELF-LUBRICATING BEARINGS • METAL FILTERS • FRICTION UNITS

Circle 434 on Page 19

When you buy Motor Starters--

YOU PAY FOR OVERLOAD PROTECTION

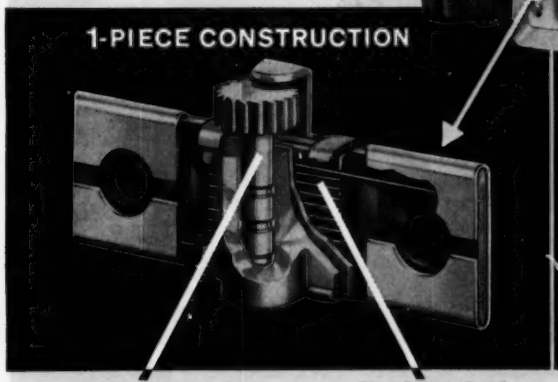
Only ONE-PIECE Overload Relays give 100% Protection • Only with ONE-PIECE construction can you *know* you've installed the heater correctly. Only with ONE-PIECE construction can you *know* the heater is exactly centered, or properly positioned, so that it performs according to its rating. Only with ONE-PIECE construction can you *know* your motors have full protection.

Only Square D has ONE-PIECE Construction • ONE-PIECE construction *eliminates* any possibility of heater misalignment. Square D melting alloy thermal overload relays can be installed only one way. They are tamper-proof. They are factory-assembled, are *individually* calibrated and tested. Repeated tripping will not affect accuracy.

Insist on Square D melting alloy thermal overload relays

***Write** for Bulletin SM-275 for the complete story on Square D starters with ONE-PIECE thermal overload relays. Address Square D Company, 4041 N. Richards St., Milwaukee 12, Wisconsin.*

...BE SURE YOU GET IT!



Heat-responsive element (solder pot) provides accurate response to overload, yet prevents nuisance tripping.

Heat-producing element is an integral part of overload unit. It's permanently joined to solder pot, can't become misaligned.

Individual factory inspection of every Square D melting alloy thermal overload relay means performance you can trust. Each unit is calibrated and thoroughly tested to make sure it will perform according to its rating.

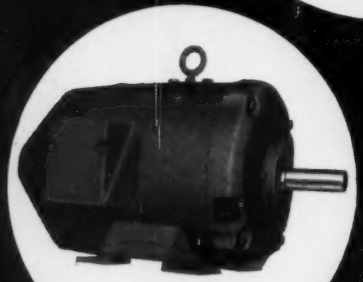
EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY

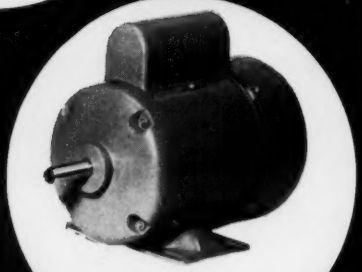
Circle 435 on Page 19

MOTORS DESIGNED WITH MACHINE TOOLS IN MIND...

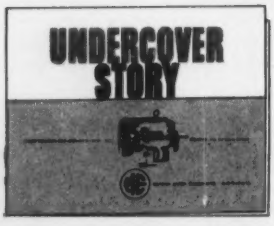
INTEGRAL H.P. MOTOR
TOTALLY ENCLOSED
FAN COOLED



DIRECT CURRENT
MOTOR



FRACTIONAL H.P. MOTOR
TOTALLY ENCLOSED
FAN COOLED



● **FREE NEW BOOKLET—"THE UNDERCOVER STORY** What To Look For *Under the Frame* In Motors For Machine Tools". 12 pages filled with information which can help you improve your products! Gives details of motor selection and application and tells of the unique Marathon engineering features that guarantee dependable operation and long motor life. Write today for your free copy!

SINCE 1913

Motors from 1/20 H.P. thru 3500 H.P. Generators from 1/2 KW thru 2500 KW

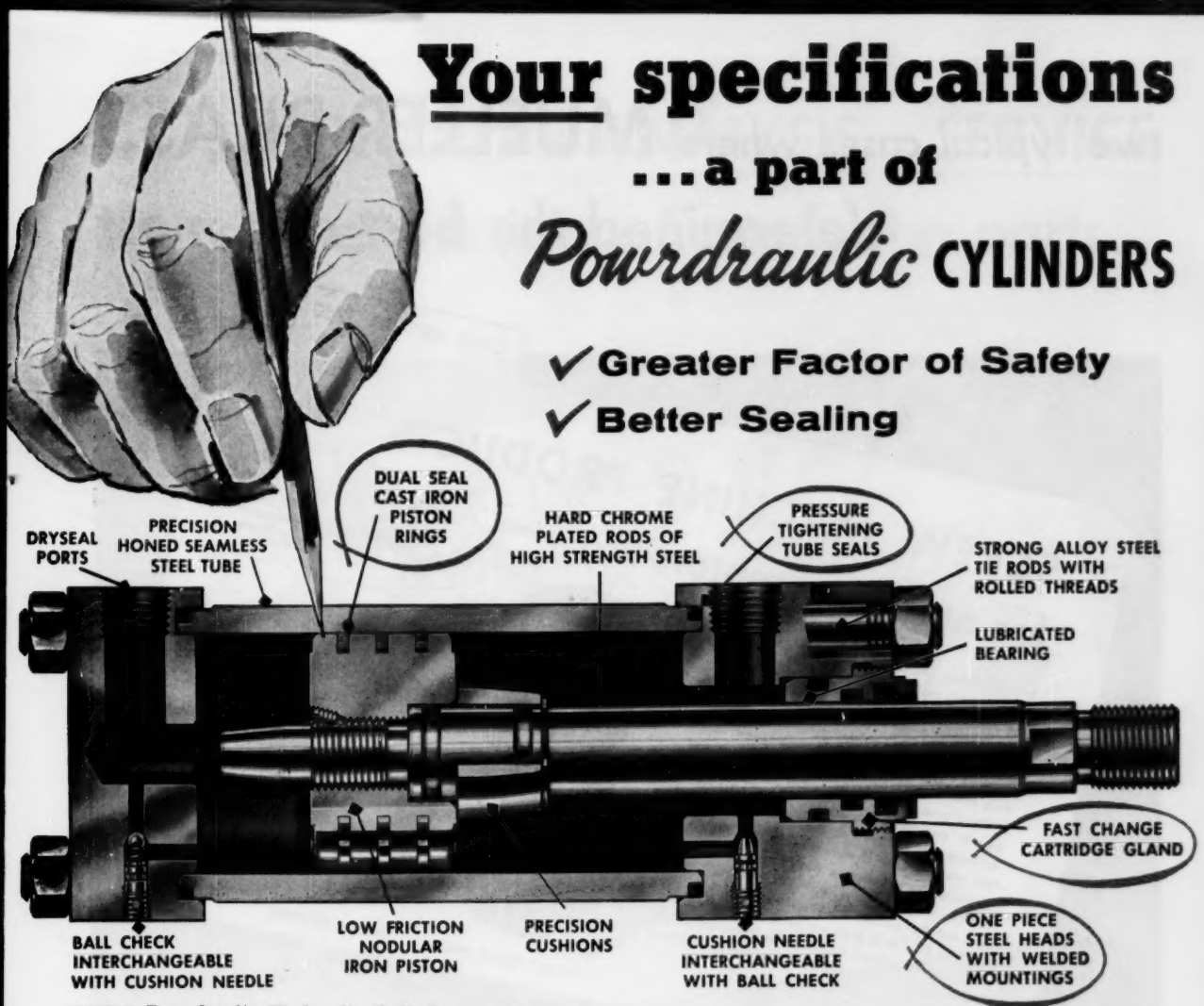
MARATHON ELECTRIC

Home Office and Factory, Wausau, Wis. Factories at Erie, Pa. and Earlville, Ill.
Sales Offices in Principal Cities

Your specifications ...a part of *Powrdraulic* CYLINDERS

✓ Greater Factor of Safety

✓ Better Sealing


DRYSEAL PORTS
PRECISION HONED SEAMLESS STEEL TUBE
DUAL SEAL CAST IRON PISTON RINGS
HARD CHROME PLATED RODS OF HIGH STRENGTH STEEL
PRESSURE TIGHTENING TUBE SEALS
STRONG ALLOY STEEL TIE RODS WITH ROLLED THREADS
LUBRICATED BEARING
FAST CHANGE CARTRIDGE GLAND
ONE PIECE STEEL HEADS WITH WELDED MOUNTINGS
BALL CHECK INTERCHANGEABLE WITH CUSHION NEEDLE
LOW FRICTION NODULAR IRON PISTON
PRECISION CUSHIONS
CUSHION NEEDLE INTERCHANGEABLE WITH BALL CHECK

HANNA Powrdraulic Hydraulic Cylinders meet J. I. C. recommendations and have industry standard mounting dimensions—2000 psi and 3000 psi non-shock. 1½" through 8" bores.

EXCLUSIVE PRESSURE TIGHTENING TUBE SEALS, located on the outside diameter of the cylinder tube, form a positive seal at all pressures from zero to maximum. Minute expansion of the tube due to pressure increases the tightness of the seal. The "O" ring is fully confined between the head and the tube and will not extrude at high pressures. Unlike other cylinders that seal at the tube ends or inside diameter, the Hanna Powrdraulic Cylinder with pressure tightening O.D. seals will remain tight at all pressures.

DUAL SEAL PISTON RINGS give you twice the sealing power of conventional piston rings. These bi-directional, cast iron rings, consisting of a ring within a ring, seal both the "in" stroke and the "out" stroke of the cylinder. The piston with dual seal rings is packed for life and never should need replacement. You may also choose the optional piston with "U" type synthetic packings.

FAST CHANGE CARTRIDGE GLAND equipped with a leak proof, low friction rod seal forms a tight seal from zero to maximum pressure. Built in rod wiper removes dirt and particles from piston rod as the rod moves "in" and serves as another hydraulic seal to wipe the rod dry on the "out" stroke. You can select either the standard gland or the optional, multiple lip, spring loaded seal. The optional gland is interchangeable and is available with synthetic rubber or Teflon* Vee packing.

ONE PIECE STEEL HEADS WITH WELDED MOUNTINGS are much stronger than conventional bolted construction and assure squareness of mountings. All mountings are designed to carry maximum cylinder loads with a generous safety margin.

Write for Catalog 900 and the name of your nearest representative.

*DuPont's registered trademark.

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES

1751 Elston Avenue • Chicago 22, Illinois

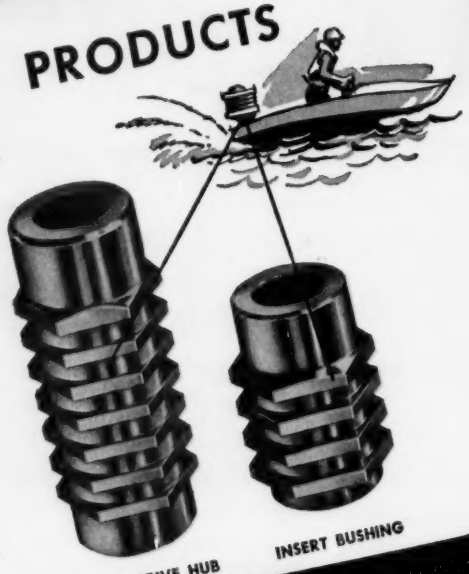
Circle 437 on Page 19

two typical cases where MUELLER BRASS *determined the best and most*

CASE HISTORY 1750

SCREW MACHINE PRODUCTS for outboard motors

Mueller Brass Co. Methods Analysis Engineers, after careful consideration of every aspect of the job requirements, found that the best method of producing these 2 outboard motor parts at the lowest cost was as screw machine products made from hollow hex rod. The insert drive hub and insert bushing are used in the lower units of one of America's most powerful outboards and must absorb constant punishment without failing. Mueller Brass Co. has one of the world's largest automatic screw machine departments fabricating both ferrous and non-ferrous custom parts. Parts can be produced in an infinite variety of shapes and sizes from ⅛" to 3¼" in a wide range of free cutting and specialized alloys. Complete facilities are available for all secondary and finishing operations, as well.



INSERT DRIVE HUB

INSERT BUSHING

THE MAN FROM MUELLER BRASS CO.

can give you sound, unbiased advice on the one best method of making your parts because Mueller Brass Co. is the only fabricator in the country offering all these methods of production. An experienced "Methods Analysis Department" has at its command a complete knowledge of the advantages and limitations of each production process. This unique technical service is your assurance of getting the best product at the best price . . . made the one best way.

FORGINGS

PLASTIC INJECTION MOLDING

MUELLER BRASS CO.

CO. METHODS · ANALYSIS · SERVICE

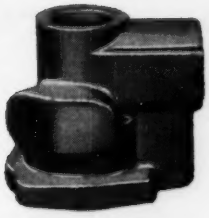
economical method of producing parts

CASE HISTORY 226

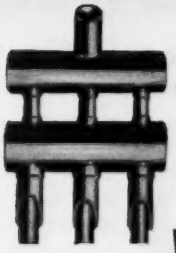
COLD-PREST® IMPACT EXTRUSION for door closer cylinder

By producing this door closer cylinder as a Cold-Prest Impact Extrusion, several important advantages are realized: formerly made in three pieces, the part is now made as one piece in one operation which eliminates machining and assembly operations. The possibility of leakage is eliminated and the part has better physical properties, as well as a smooth, bright finish. Mueller Brass Co. has complete facilities for producing Cold-Prest impact extrusions of aluminum, copper, brass, bronze and steel. Square, rectangular and cylindrical shells up to 28" in length are possible depending on wall thickness and other design details. Parts can be designed having ribs, flutes, splines or bosses . . . with multiple wall diameters and with various wall sections.

POWDERED METAL PARTS



SAND CASTINGS



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MADE IN U.S.A. TO THE STANDARDS OF AMERICAN INDUSTRY

Write today for engineering manuals covering all these production processes.

PORT HURON 20, MICHIGAN

270

Another new development using

B.F.Goodrich Chemical *raw materials*

These tool handles are molded in various colors by Fawick Flexi-Grip Company, Akron, Ohio. B.F.Goodrich Chemical Company supplies the Hycar nitrile rubber.

Handles of Hycar help tool users come to grips with grease problems

These colorful tool grips are molded especially for use in gas stations, machine shops and maintenance areas. Unlike handles molded with conventional rubber, they won't get soft and sticky in shop use. Hycar nitrile rubber resists oil, gas, chemicals and solvents.

Hycar wears and wears because of its toughness and unusual abrasion resistance. It's no wonder that since they've started equipping tools with handles of Hycar, tool makers are experiencing measurable increases in sales.

Hycar nitrile rubber has wide application wherever gas, oil or chemicals may be a problem—or wherever you need extra abrasion resistance, strength or flexibility. There are many different types of Hycar rubber available—in latex form as well as dry rubber. For more information, write Dept. CM-4, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Hycar
REG. U. S. PAT. OFF.
Rubber and Latex

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich

GEON polyvinyl materials • HYCAR rubber and latex
GOOD-RITE chemicals and plasticizers • HARMON colors

RACINE-SECO

Hydraulic Valves

DIRECTIONAL CONTROL VALVES
Valves 4-way and 2-way

Designed to conform with J.I.C. specifications. All sizes 3/8" to 2" — foot or sub-plate mounted, with neutral porting arrangements to suit your needs. Pressure rated up to 1500 psi. Sleeve type construction permits controlled acceleration or deceleration of a cylinder or fluid motor.

Check Valves

For high pressure unloading of pumps, opening and closing accumulator lines and when properly grouped for use as high pressure directional valves for 3-way or 4-way functions. Sizes 3/8" to 2" up to 10,000 psi. Design conforms with J.I.C. specifications.

VOLUME CONTROL VALVES

Pressure compensating and non-compensating types available. 1/4" to 2" sizes. Pressure compensating valves are ideal for Meter In, Meter Out or Bleed-Off control of accurate oil flow.
Non-compensating valves provide an adjustable flow rate by varying the adjustable orifice. Designed to J.I.C. standards.

PRESSURE CONTROL VALVES

A complete line including Relief, Sequence, Counterbalance, Resistance and Counterbalance and Pressure Reducing Hydraulic Valves. Sizes 3/8" to 1 1/4". 100 to 1500 psi pressure range.

Write for complete descriptive catalog No. 59-A

RACINE SECO

RACINE HYDRAULICS & MACHINERY, INC.
RACINE, WISCONSIN
One Source — One Responsibility for all your hydraulic circuit needs

Circle 440 on Page 19

The Heat's On

precisely . . . under the dependable control of Fenwal Standard Thermoswitch® Units

Key step in the manufacture of milk cartons on Pure-Pak carton-forming machines is the heat-sealing of the bottom flaps. For eight years this manufacturer has used Fenwal Series 17000 THERMOSWITCH units for temperature control of this vital operation. Result: eight years of precise troublefree control. *That's time-tested performance!*

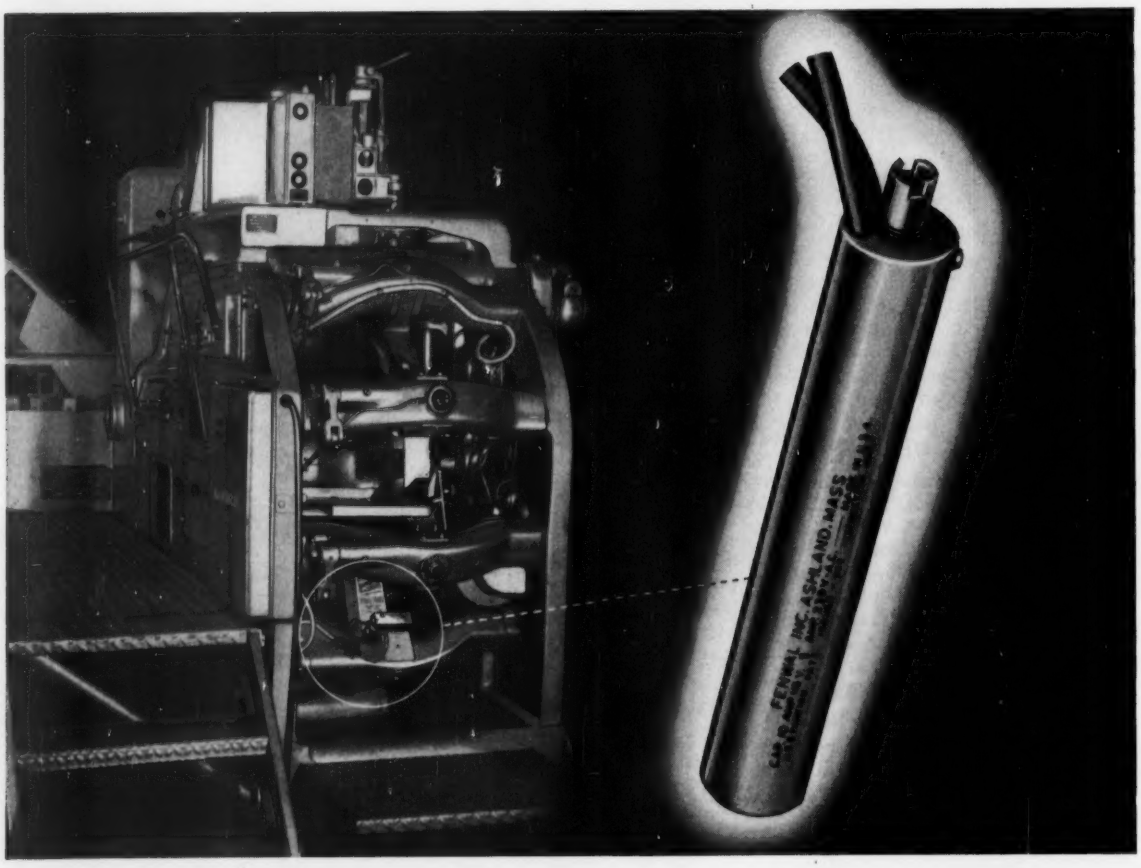
It's typical of the hundreds of successful installations of immersion and surface-mounted THERMOSWITCH units . . . in tanks, vats, air ducts . . . for widely varying space and position requirements . . . under the severest conditions of shock, vibration, and corrosion. *They're standard units with truly special capabilities!*

Yet for all their ruggedness, THERMOSWITCH units are sensitive to temperature changes of only a fraction of a degree. Heat sensitive outer shell responds instantly and accurately. *No thermal lag . . . no control error!*

Use these versatile units for control applications from −100 to +1100°F. They're completely adjustable with current ratings up to 10A-115VAC.

For complete details, write Fenwal Incorporated, 198 Pleasant Street, Ashland, Mass.

Compact, totally-enclosed Fenwal THERMOSWITCH units provide positive, service-free control of heat-sealing operation on this Pure-Pak carton-forming machine.

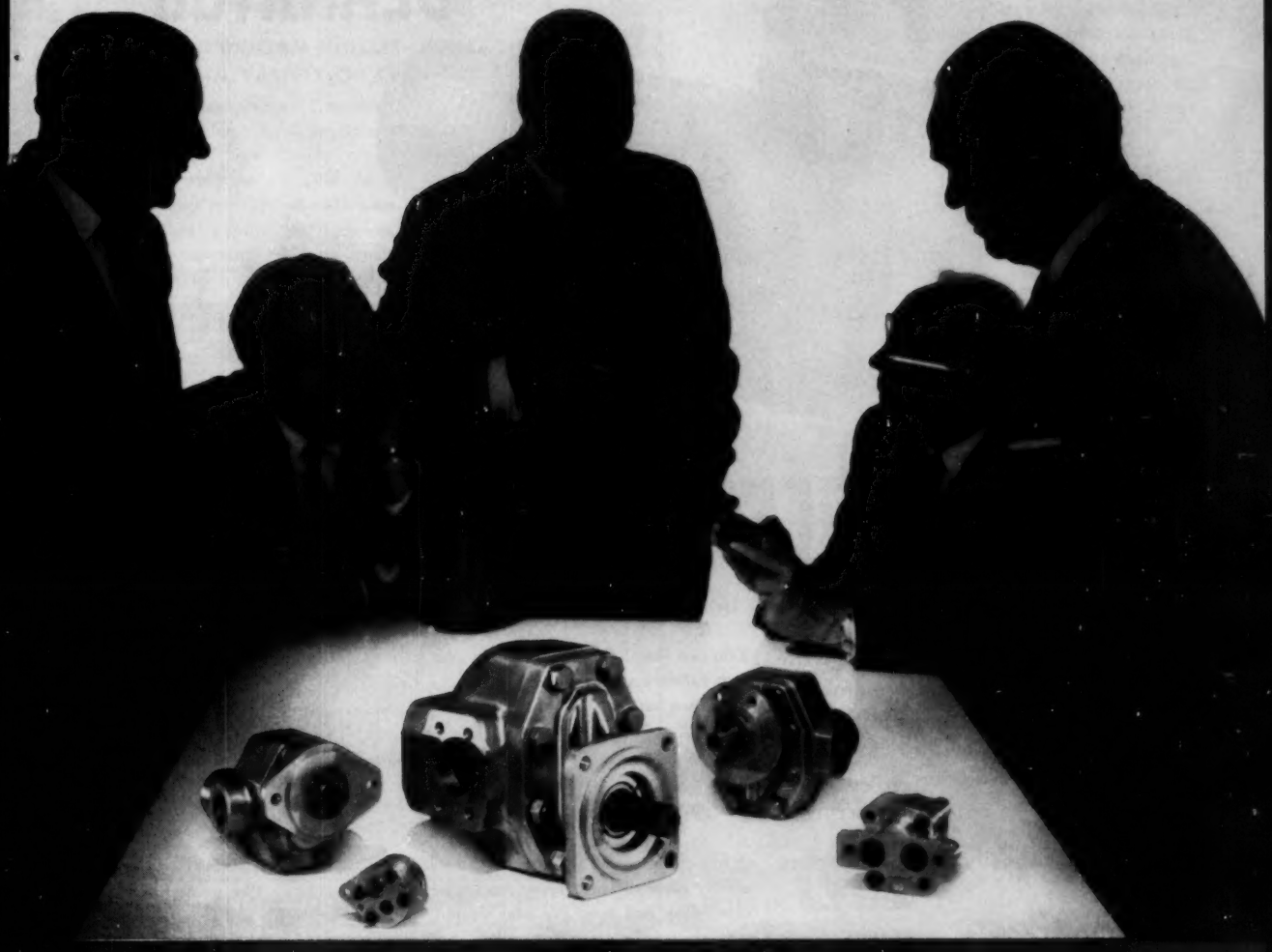


ANOTHER EXAMPLE OF HOW **Fenwal** CONTROLS TEMPERATURE . . . PRECISELY

Circle 441 on Page 19

EXPERIENCE

builds a line of HYDRAULIC PRODUCTS



Take another look at the pumps pictured above. They're samples of an important, improved, top-quality line: *HP. Hydraulic Products Division* of Clark Equipment Company.

Behind this line is the know-how of five 20-year veterans of the hydraulic business . . . and the backing of a company old in industrial experience and known throughout the world for dependable, high-quality products.

Hydraulic Products pumps, motors, and valves are planned, in light of all this experience, to eliminate your most serious hydraulic component problems. *Quality* and *dependability* are probably the most important gains . . . HP products are built in a plant with all new tooling and the latest in automatic 100% testing. HP products are aluminum . . . compact and light in weight. Every HP product is designed for easy servicing . . . you can, for example, reseal or even rebuild an HP pump in the field without loss of efficiency.

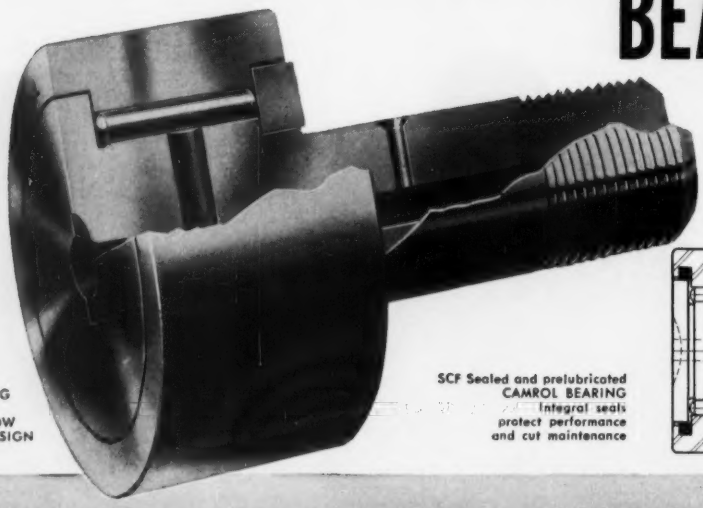
Visit our plant. Write for our catalog or, better still, for immediate information pick up the phone and call us—Benton Harbor WAlnut 6-2133.

CLARK EQUIPMENT

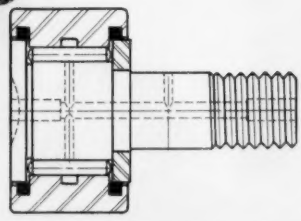
HYDRAULIC PRODUCTS DIVISION
CLARK EQUIPMENT COMPANY
Miller Street Plant
Benton Harbor, Michigan

Circle 442 on Page 19

McGILL® CAMROL® BEARINGS



CF CAMROL BEARING
CUT AWAY TO SHOW INTEGRAL STUD DESIGN



SCF Sealed and prelubricated CAMROL BEARING
Integral seals protect performance and cut maintenance

SIMPLIFY DESIGN and ASSEMBLY

Stock sizes eliminate the cost of procuring and assembling improvised unit components

You can simplify design and cut cost with CAMROL precision anti-friction cam followers—built for the job. Complete units, with established performance ratings are available from stock in standard roller diameters from ½″ to 4″. Capacities to 20,480 lbs. at 100 R.P.M.

Precision anti-friction bearing accuracy

Precision construction, including concentricity of stud to outer race OD, provides accurate alignment of machine members.

High load capacity in limited space

A full complement of race width rollers provides maximum capacity and ability to withstand heavy intermittent shock loading. The extra heavy outer ring and specially heat treated stud add durability and insures dependability of machine operation. Bolt mounted ball bearings crack under equivalent loads and plain bearings require constant oil lubrication.

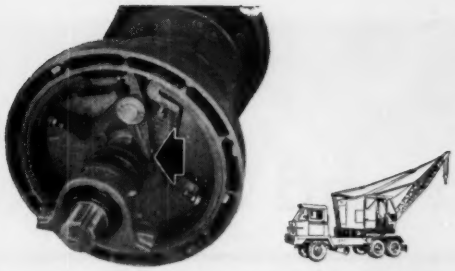
Integral seals retain lubrication —keep dirt out

SCF Sealed CAMROL bearings are interchangeable dimensionally with standard CAMROL bearings. They are pre-lubricated and have a ferrous oxide finish to resist corrosion. Effective sealing against contamination reduces machine maintenance.

Camrol CYR series

In the CYR Series, an inner race replaces the stud for yoke or shaft mounting. Standard and sealed CYR bearings are available in the same stock sizes as CF and SCF Series.

SEND FOR McGILL BEARING CATALOG NO. 52-A. for complete data on McGill CAMROL, GUIDEROL, MULTIROL and CAGEROL bearings.



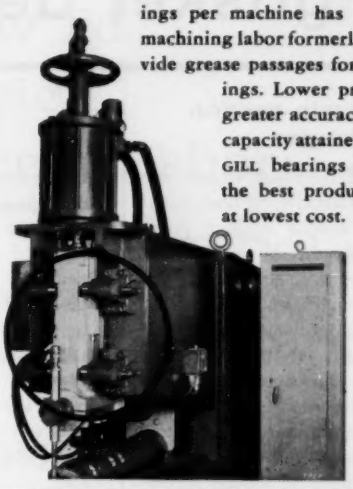
SCHIELD BANTAM UTILIZES CF BEARING ADVANTAGES IN VARIETY OF APPLICATIONS.

The Schield Bantam Company has applied CF bearings in internal clutch band operating arms, turn controls, swing and travel shaft clutch cones, engagement controls and speed shift collars. The photo above shows how CF-1 bearings are applied to Drum Clutches in Schield Bantam Series 350 cranes and shovels.

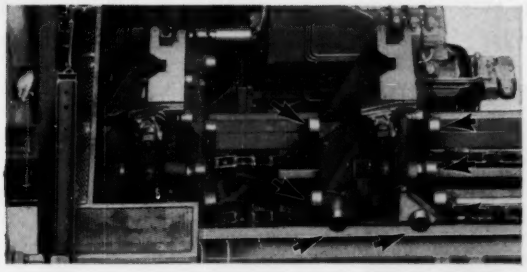
This company replaced bronze collars and yokes and reports cost savings through the use of CAMROL bearings. In addition they have increased capacity and have experienced improvement in length of life and maintenance factors. This has added to the over-all efficiency and dependability in heavy equipment where "down-time" is extremely expensive.

ACRO WELDER REDUCES PRODUCTION COSTS, IMPROVES ACCURACY WITH SCF BEARINGS

SEALED CAMROL bearings are used to accurately locate and guide the welding ram in spot welders made by ACRO WELDER MFG. CO. The user reports that the use of 12 prelubricated CAMROL bearings per machine has saved hours of machining labor formerly needed to provide grease passages for unsealed bearings. Lower production costs, greater accuracy and high load capacity attained with these McGILL bearings help to assure the best product performance at lowest cost.



—insure precision performance in cam follower, track and guide roller applications



BUHR MACHINE TOOL CUTS FRICTION TO REDUCE HORSEPOWER WITH SEALED CAMROL BEARINGS

Production parts are drilled, milled, bored and tapped in automated systems engineered and built by the BUHR MACHINE TOOL COMPANY. The moving fixtures which hold parts being machined are guided and carried on McGill sealed CAMROL bearings as shown in the close-up above. By reducing starting and running friction to an absolute minimum, the CAMROL bearings have made horsepower requirement reductions possible in these systems. Ample load capacity, high resistance to shock loads and integral seals which retain lubricant and keep out contamination have held maintenance down. 8 SCF-3 CAMROL bearings guide and support each fixture.

J. I. CASE USES SCF AND SCYR CAMROL BEARINGS IN HAY BALER

The bale compressing plunger of the J. I. Case Model 177 Heavy Duty Hay Baler rolls on CF-2¾-S CAMROL Bearings and CYR-1¾-S Bearings guide the plunger.

Anti-friction bearing dependability and trouble-free performance are essential in this type of field equipment where bearing failure may result in loss of valuable harvesting time.

Integral bearing seals in these CAMROL bearings, keep relubrication requirements low and protect internal bearing components from field dirt, dust and moisture.

In addition to accurate, dependable action with minimum friction, high quality McGill CAMROL bearings offer savings on production and assembly.

engineered electrical products

McGILL®

precision needle roller bearings

MULTIROL-GUIDEROL-CAMROL-CAGEROL

McGILL MANUFACTURING CO., INC., Bearing Division
200 N. Lafayette Street, Valparaiso, Indiana

Circle 443 on Page 19

(Advertisement)

Technical data for gasket design and selection

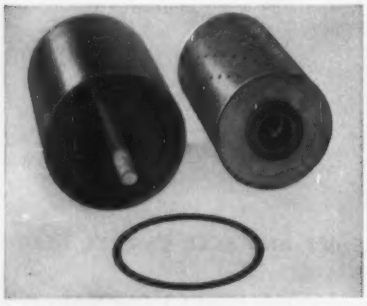
Sealing thin-section flanges

Very narrow flanges—as found, for example, on automotive oil filter housings—present unique sealing problems which should be considered when the gasket is selected.

On narrow flanges, and particularly where internal pressures must be sealed, unit loads on the gasket are very high. This can cause crushing or extruding of the gasket, a tendency that is more pronounced where ambient temperatures are above 200° F.

If assembly methods require screwing a narrow flange into place (on grease guns, for instance), there is a risk of the flange acting like a circular knife, cutting or tearing the gasket material.

A new asbestos gasket—Armstrong Accopac AN-890—has the right combination of properties to provide a seal



This automotive oil filter housing is typical of thin-section flanges that can be sealed economically with Accopac AN-890.

on such flanges. AN-890 is a dense, homogeneous sheet, free of clumps and bunches of fibers. It will withstand crushing and extruding at loads as high as 100,000 psi.

Accopac AN-890 is economical, too. Gauge for gauge, it is 15% to 30% less expensive than conventional compressed asbestos. And in many applications, its high sealing efficiency permits gasket gauge to be reduced as much as 50%.

Our bulletin IND-915 will give you more information on Accopac AN-890. Write for a copy.

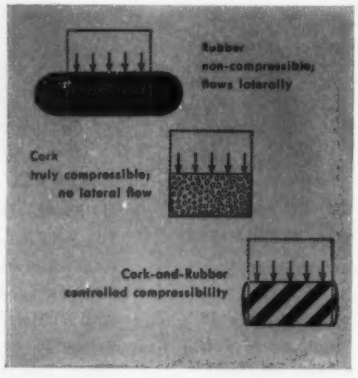
How to cut the cost of O-rings

If you now use molded rubber O-rings, chances are you can reduce costs considerably by changing to lathe-cut rings of Armstrong cork-and-rubber materials. At the same time, it may be possible to effect savings in machining time and inventory costs. Here's why.

Molded rubber O-rings are incompressible and must be made to very close tolerances to insure perfect fit between the flanges. An O-ring too small in cross-section will not seal . . . and an oversize ring will prevent flange contact.

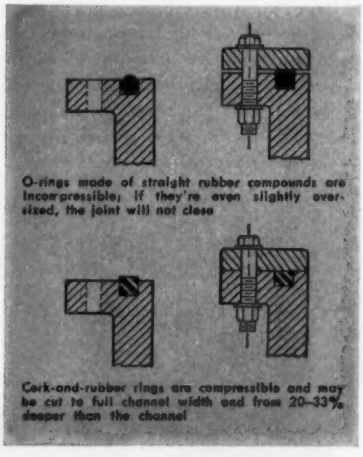
Cork-and-rubber rings help you avoid this difficulty because they combine the compressibility of cork with the non-compressibility of rubber. The per cent of compression for cork-and-rubber rings may range from 20% to 33%.

This compressibility permits wider tolerances in the flanges . . . and can



produce worthwhile savings in machining time. Or it may allow you to reduce inventories by using one size cork-and-rubber ring where two or more molded sizes were needed previously.

In other important characteristics, cork-and-rubber rings behave much the same as molded rings made of the same base polymer. For example, the solvent resistance of a lathe-cut ring made of nitrile-type rubber and cork would be equal to a molded ring made


O-rings made of straight rubber compounds are incompressible; if they're even slightly oversized, the joint will not close
Cork-and-rubber rings are compressible and may be cut to full channel width and from 20–33% deeper than the channel

of a straight nitrile compound.

In such characteristics as heat resistance, imperviousness, and sealing of internal pressures, cork-and-rubber rings will perform just the same as rings molded of the corresponding base polymer.

Armstrong cork-and-rubber rings are available in any size from ⅜" to 20" I.D. Much additional information on designing with Armstrong cork-and-rubber gasket materials is contained in our Gasket Design Manual.

For your copy of the Armstrong Gasket Design Manual, write to Armstrong Cork Company, Industrial Division, 7108 Dean St., Lancaster, Pa.

Armstrong GASKET MATERIALS

. . . used wherever performance counts

How To Design Excess Labor *Out* Of Your Product with MADISON-KIPP zinc and aluminum die castings

Please ask a traffic officer to open a Magee-Hale Park-O-Meter for you. Inside of this product you will see a prime example of the maximum utilization of the die casting process.

The skilled and cost-conscious mechanics at Madison-Kipp worked closely with the meter designers to attain both excellence of appearance and low secondary labor content.

Please clip this ad as a reminder to contact us when you have die casting requirements.

kipp

MADISON-KIPP CORPORATION
210 Waubesa Street • Madison 10, Wisconsin

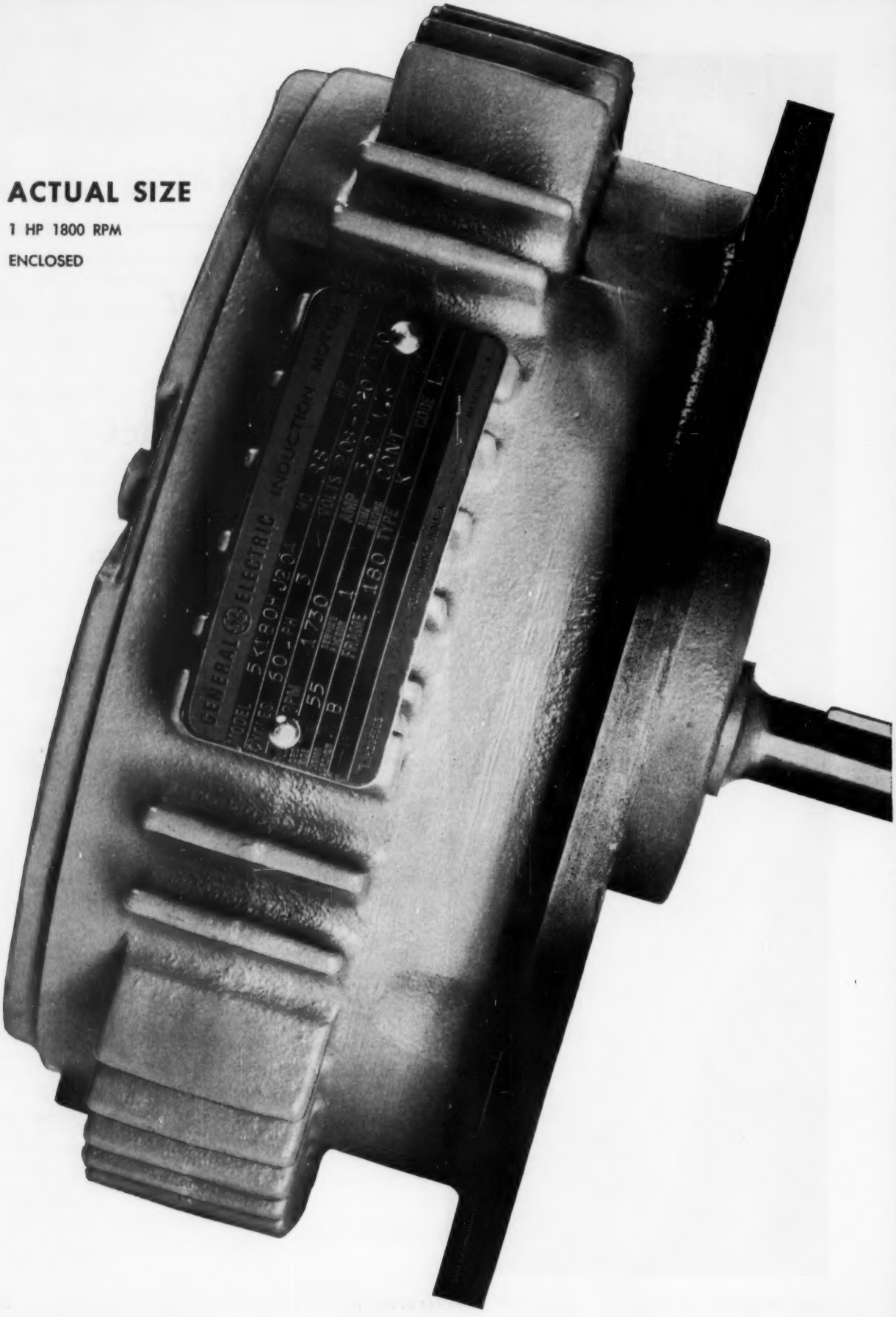
• Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering
• Originators of Really High Speed Air Tools

Circle 444 on Page 19

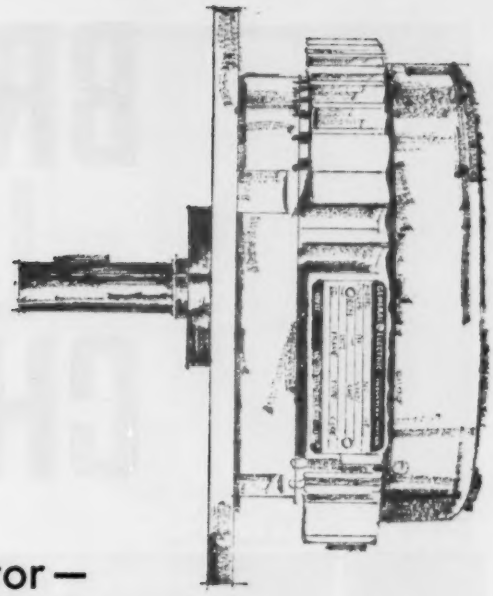
ACTUAL SIZE

1 HP 1800 RPM

ENCLOSED



NEW



General Electric Thinline Motor—

SHORT, LIGHT AND VERSATILE

You can easily eliminate one of your motor installation problems with General Electric's new polyphase motor for limited-space mounting.

Up to eight inches shorter and 26 pounds lighter than standard flange-mounted motors, General Electric's new Thinline motor will let you meet your horsepower requirements in considerably reduced installation space. By getting more horsepower in less space, you will be able to design more compact equipment in the future. On your present equipment, the Thinline motor's smaller overhang reduces required equipment space or gives operators more working area.

Easier to handle and position during installation, the Thinline motor minimizes mounting problems. Your assemblers will be able to work faster with less fatigue. And the 26-pound weight reduction lets you save substantially on shipping costs!

A wide choice of enclosures and mounting dimensions adds versatility to the Thinline motor's flange-type design. Thinline motors are available from 1 to 5 HP in both dripproof and totally-enclosed constructions.

Mounting versatility is provided by your choice of *three* mounting flanges for each Thinline motor rating. Any of the three available flanges (see the chart below) can be used for all-angle mounting—without adding to motor length.

You can get the answer to your Thinline motor application question simply by calling your nearby General Electric Apparatus Sales Office. If you have not received your copy of General Electric's Thinline motor publication, write to Section 840-28, General Electric Co., Schenectady, N. Y. Ask for Bulletin GEA-6927.

INTERCHANGEABLE FLANGE DIMENSIONS

Horsepower at 1800 rpm	Outside Diameter of Flange in Inches		
	Standard	Modified "D"	Alternate
1 hp	10.25	11	12
1½ and 2 hp	12	11	10.25
3 hp	13	11	14
5 hp	14	11	13

KNOWN APPLICATIONS

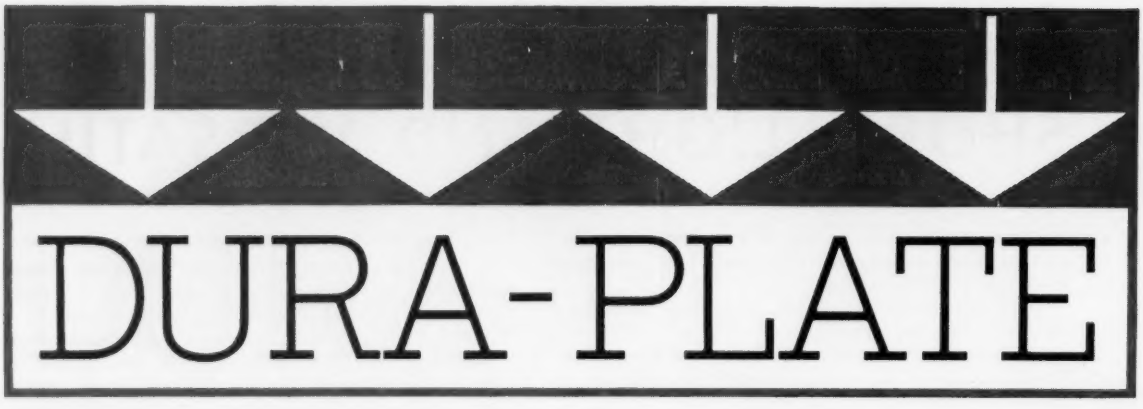
Fans and Blowers
Food Machinery
Textile Machinery
Floor Machinery
Paper Machinery
Pumps and Compressors
Machine Tools and Metalworking Machines

Progress Is Our Most Important Product

GENERAL ELECTRIC

Circle 445 on Page 19

BROWN LIPE CHAPIN



New Chrome Plating advance gives bright work new dimension in durability!

Here's a shining example of the many benefits available for your products at Brown-Lipe-Chapin. It's Brown-Lipe-Chapin's new DURA-PLATE! This new and unique process of chrome plating gives your product active sales appeal with the rich quality of gleaming chrome . . . and adds a new depth of durability that will last the life of your product.

DURA-PLATE consists of two layers of laminar and columnar nickel with a layer of chrome *five times as thick* as produced by conventional methods. The result is a surface almost impenetrable to corrosion. DURA-PLATE can be applied on any product made of steel, or on zinc die castings . . . at no extra cost!

DURA-PLATE is the result of the advanced research, the development of new techniques and thorough testing that continue at Brown-Lipe-Chapin to help make your products better.

DURA-PLATE is typical of the many benefits you get from Brown-Lipe-Chapin when you call on their extensive facilities for die casting, metal stampings of all kinds, electroplating, anodizing and painting.

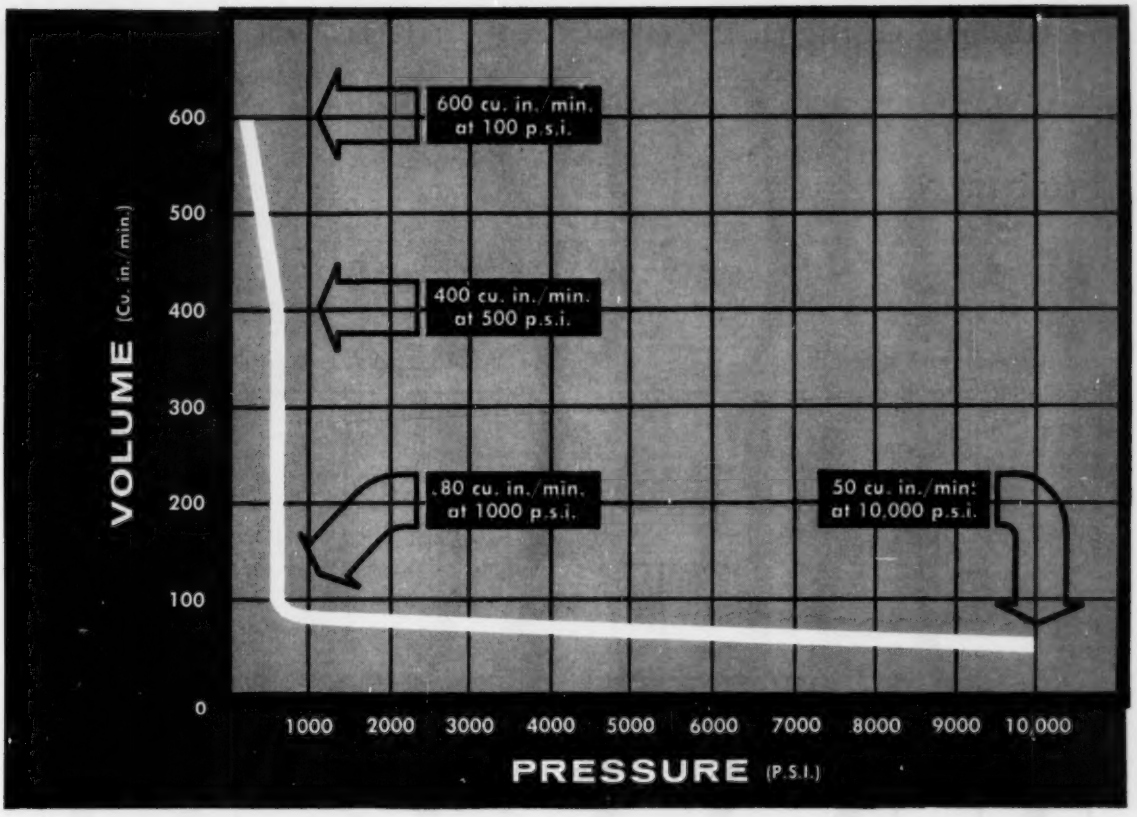
If you're looking for a bright difference in your product, call on Brown-Lipe-Chapin, Division of General Motors Corporation, Syracuse, New York.

GM GENERAL MOTORS

RELIABILITY by BROWN·LIPE·CHAPIN

DIVISION OF GENERAL MOTORS CORPORATION

Circle 446 on Page 19



New Hydraulic Pump! Look Again at the Curve!

- **LIGHTWEIGHT, TWO-STAGE "POWER PACKAGE"**
- **WT. ONLY 45 LBS., 10¾" x 12⅝", 17½" HIGH**

The amazing, new OTC "Vanguard" hydraulic pumping unit is a quiet-operating, precision-built, two-stage hydraulic pump, driven by a universal motor, and consisting of a gear pump for the low pressure stage and a five-cylinder, axial-piston pump (which is supercharged by the gear pump) for the high pressure stage.

All wearing parts are made of finest tool steel, heat-treated and ground and lapped to assure efficiency and long life.

A variety of valves, controls and accessories are available and are easily mounted to meet your particular requirements.

Here is a power package that might well revolutionize much of tomorrow's designing in high pressure. Your interest, in reading this far, is well founded!

For bulletin and complete information, write:

RESEARCH · ENGINEERING · DEVELOPMENT · OTC

PRECISION HYDRAULICS DIVISION

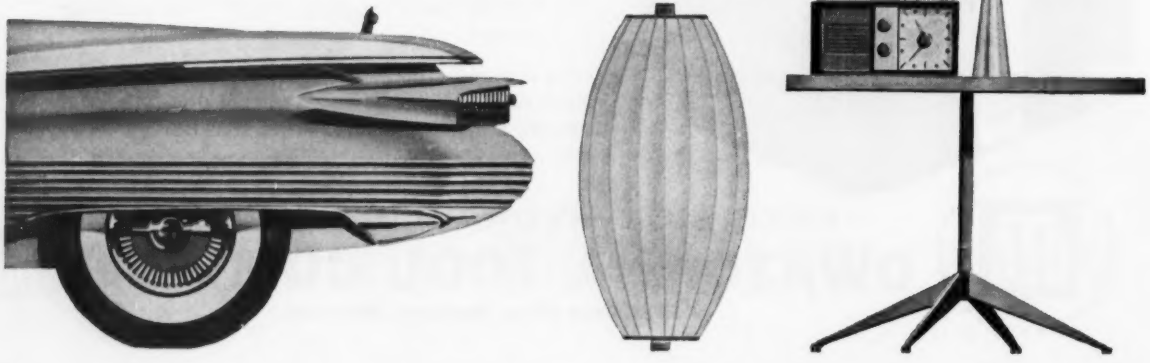
OWATONNA TOOL COMPANY

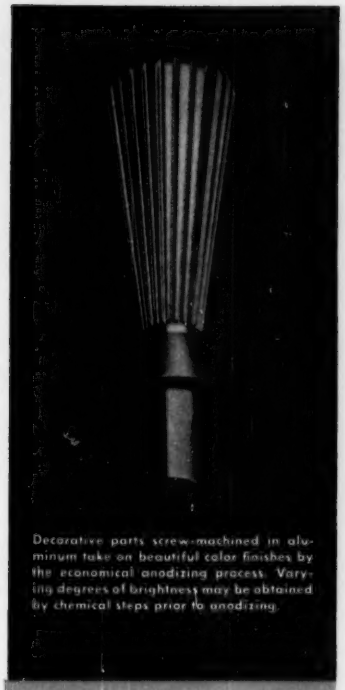
712 N. Cedar Street, Owatonna, Minnesota

Circle 447 on Page 19

What the designer conceives...aluminum achieves

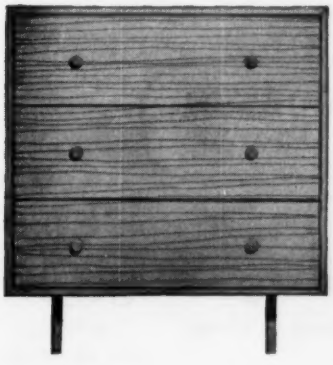
COLOR BEAUTY NATURAL BEAUTY





Decorative parts screw-machined in aluminum take on beautiful color finishes by the economical anodizing process. Varying degrees of brightness may be obtained by chemical steps prior to anodizing.

Clear-anodizing produces a jewel-hard coating that protects aluminum's natural silvery beauty—and at far less finishing cost than other processes such as plating or polishing.



AND SAVINGS WITH SCREW MACHINE PRODUCTS IN ALUMINUM

You save on material, you save on finishing, and you save on over-all cost when you design with aluminum! (See cost comparisons at right.)

As in the finished shapes shown, aluminum offers exceptional design versatility in the screw machine process . . . sharp, clean lines . . . and unusually fine "as-machined" finish.

In the screw machine process, aluminum's excellent machinability makes possible production versatility. High production rates plus low tooling cost assure initial savings as well as model-change economy.

Aluminum offers still more useful properties, such as light weight with high strength, corrosion resistance, non-sparking and non-magnetic qualities.

Kaiser Aluminum does not manufacture screw machine parts, but does offer technical assistance to parts suppliers throughout the country. Contact your local screw machine products manufacturer for further information and quotations on specific parts in aluminum.

Kaiser Aluminum & Chemical Sales, Inc.
1924 Broadway, Oakland 12, Calif.

KAISER ALUMINUM

See "Maverick" • Sunday Evenings, ABC-TV Network
Consult your local TV listing.

COST DATA FOR 1000 PIECES*

	Aluminum	Brass
Material (53 lbs.)	$28.28	(159 lbs.) $52.86
Less 47% scrap (@ 16.5¢/lb.)	4.13	(@ 18¢/lb.) 13.58
Total Material Costs	$24.07	$39.16
Machining	11.80	11.80
Approximate Tooling Costs ($190)	1.90	1.90
Color Anodizing	10.00	
Total Cost	$47.77	$52.86

Total Savings per 1000 pieces $ 5.09 (In Aluminum)

(An unlimited number of metal banded colors are available with aluminum—obtainable in other metals only by less durable surface coatings.)

COST DATA FOR 1000 PIECES*

	Aluminum	Brass
Material (73 lbs.)	$37.74	(218 lbs.) $66.05
Less 52% scrap (@ 16.5¢/lb.)	6.27	(@ 18¢/lb.) 20.34
Total Material Costs	$31.47	$45.71
Machining	25.85	25.85
Approximate Tooling Costs ($200)	2.80	2.80
Clear Anodizing	10.00	
Chrome Plating		15.00
Total Cost	$69.12	$88.36

Total Savings per 1000 pieces $19.24 (In Aluminum)

*(These are estimated costs based on runs of 100,000 pieces)

Kaiser Aluminum & Chemical Sales, Inc.,
Dept. SM-1065
1924 Broadway, Oakland 12, California

Please send me the free "Color Beauty" booklet with cost data and color-anodizing information for aluminum screw machine parts.

NAME _____

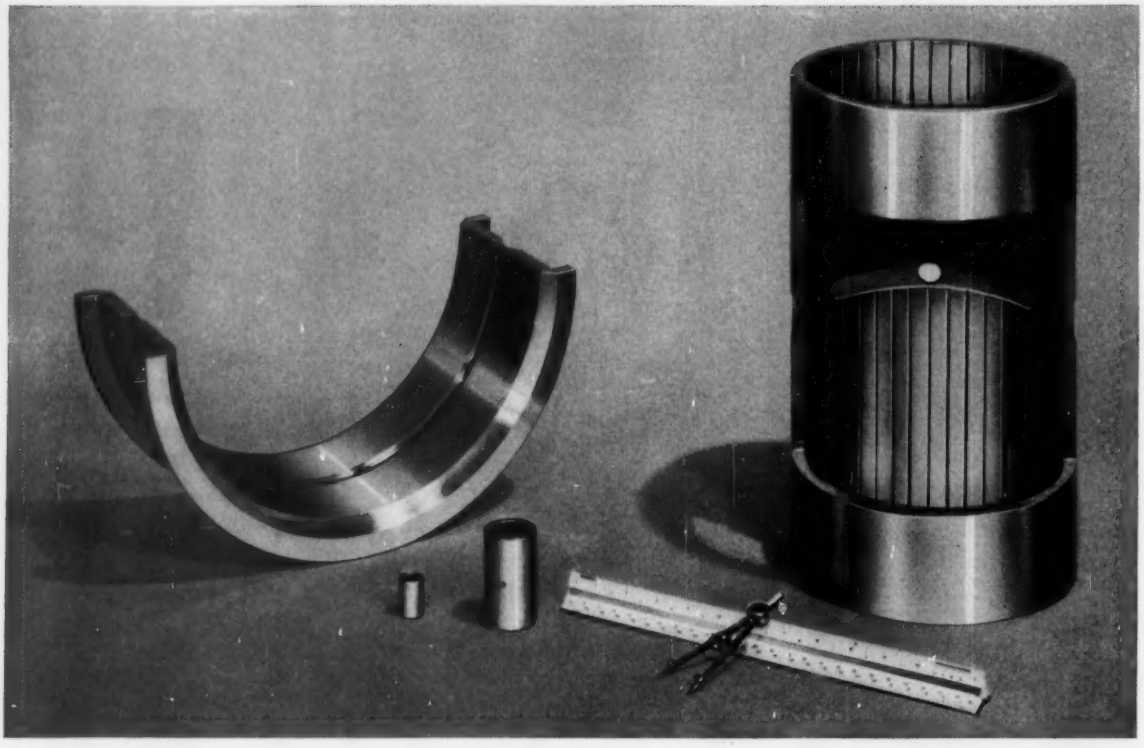
COMPANY _____

ADDRESS _____

CITY _____

STATE _____

Circle 448 on Page 19



Big or small, Johnson cast bronze bearings lick the tough jobs

BIG or small, Johnson Bearings, plain, grooved or designed for solid lubricants—up to 30-inch lengths—are precision-designed to give trouble-free performance, plus long life in demanding applications where heavy duty is a factor . . . or where . . .

- **it may be difficult to lubricate or lubrication may be neglected.**
- **high temperatures may rule out ordinary oils or greases.**
- **temperatures are too high or speeds are too slow to sustain an oil film.**

Available plain, with oil grooves, plug type or serrated type graphite, these tough Johnson bearings can be custom-made easily for rigorous applications. Serrated types are available from stock in more than 175 sizes; plain bearings in more than 900 stock sizes. For special applications *twenty-five* quality Johnson alloys are yours to choose from to assure the inherent quality of these bearings—plain or flanged.

To get the bearing you need for an economical investment, call, write or wire Johnson Bronze Co., 525 South Mill Street, New Castle, Pa. Do it today.

Johnson Bronze

525 South Mill Street • New Castle, Pa.

Subsidiary: Apex Bronze Co., Oakland, Cal.

JOHNSON Bearings

POWDER METALLURGY—BRONZE OR IRON

ALUMINUM ON STEEL SOLID ALUMINUM

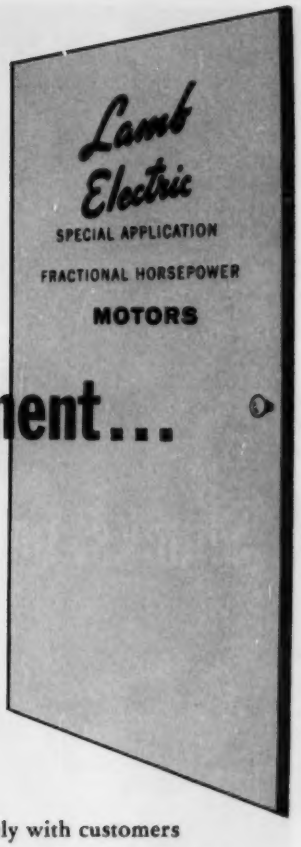
BRONZE ON STEEL

STEEL AND BABBITT

GRAPHITED BRONZE

BRONZE—CAST OR ROLLED

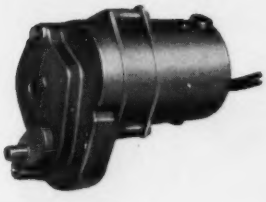
Circle 449 on Page 19



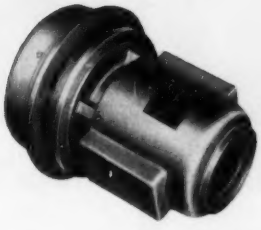
The door to your motor department...

27 Volt DC shunt wound aircraft motor qualified to specification MIL-M-8609A (ASG) for small high speed pumps. Frame 1 27/32 x 1 1/8

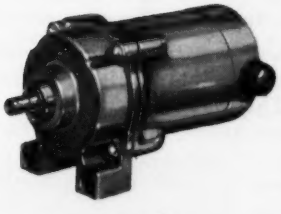
Impact drill motor for putting threaded inserts in concrete. Designed to withstand heavy vibration. Frame 3 11/16 x 1 3/4



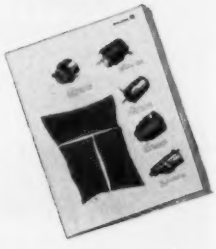
Two-stage helical gearmotor with crank on output shaft to operate circuit breaker. Frame 2 3/16 x 1 1/2



3/8 Horsepower motor with two-stage fan, Underwriters' labeled for explosion-proof vacuum cleaners.



Differential planetary gear train allows for unusually compact design in this miniature gearmotor for business machines. Frame 1 5/16 x 15/16



NEW!

8-page Folder describes these and other Lamb Electric motors. Send for your copy.

We work so closely with customers that many consider our facilities a part of their own operations.

In addition to direct field contact through District Engineers, customers are welcome in our plant to consult with various parts of our organization.

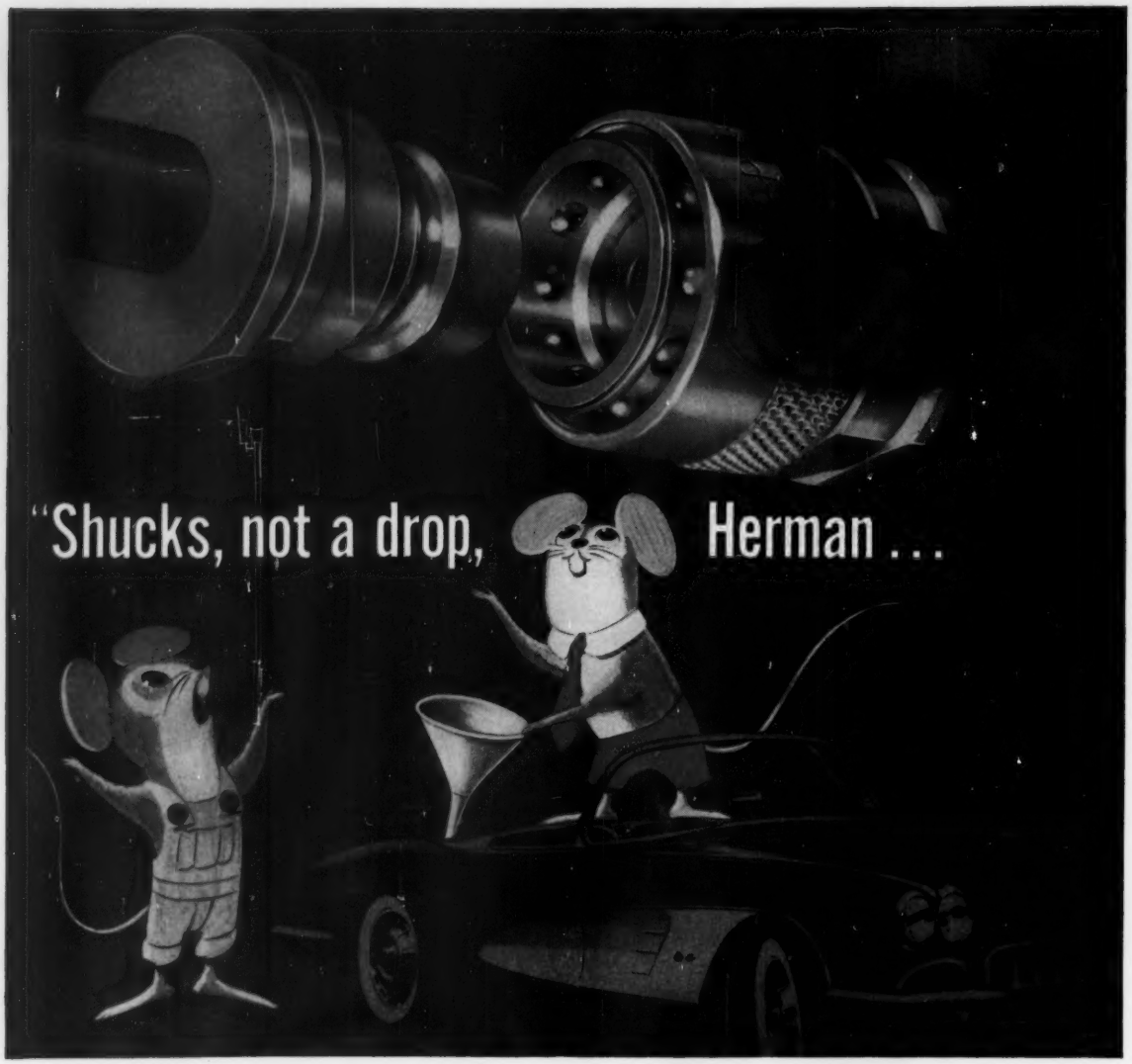
Close cooperation of our staff with your purchasing and engineering departments can mean improved dependability of your motor-driven product, reduced weight, greater compactness and delivery of production quantities on time and at the lowest possible cost.

THE LAMB ELECTRIC COMPANY · KENT, OHIO

A Division of American Machine and Metals, Inc.
In Canada: Lamb Electric—Division of Sangamo Company Ltd.—Leaside, Ontario

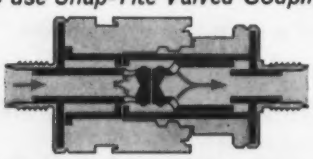
Lamb Electric
SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

Circle 450 on Page 19

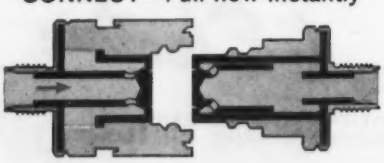


. . . it's a no-spill valved coupling by Snap-Tite!"

To use Snap-Tite Valved Coupling:



CONNECT—Full flow instantly



DISCONNECT—Stop flow instantly

The 15 Series valved coupling automatically snaps off the flow of the most volatile fluids when disconnected—with no leakage.

Snap-Tite's 15 Series valved coupling contains valves in both sections. Thus, the only fluid lost is that which clings to the outer metal surfaces. This coupling meets military specifications and can be used with fuels and other fluids to 3000 psi working pressure and 400°F. Sizes: ¼", ½", ¾", 1" in 6061T6 aluminum anodized; ⅜" in steel (electroless nickel plated), and 6061T6 aluminum.

Snap-Tite can provide the right valved coupling—with quick off-on action wherever coupling or shut-off is required—for most any use, most any fluid.

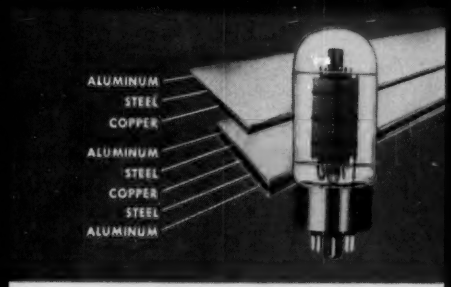
For more information, write for Snap-Tite Catalog #15. Snap-Tite representatives in all principal cities.

★ Snap-Tite

UNION CITY 11, PA.

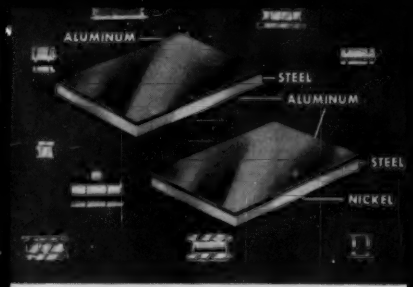
ST-59-03

Circle 451 on Page 19



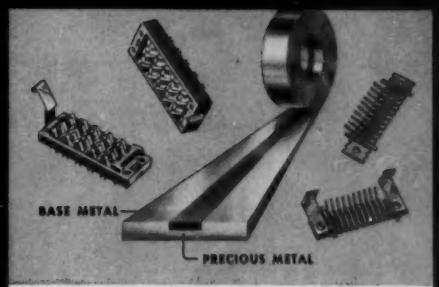
ALIRON® Copper-Base and Copper-Cored

Three-layer and five-layer materials used for anodes in rectifier and amplifier tubes. Provide longer power output life . . . uniform heat dissipation . . . high electrical conductivity . . . improved anode reradiation . . . and reduce costs.



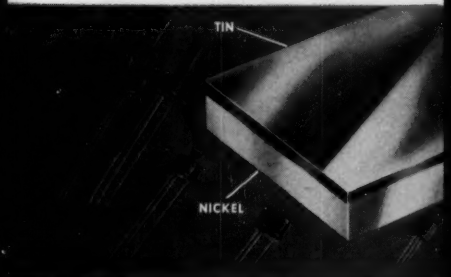
ALNIFER®, NIFER®

These clad metals are used as alternate materials for solid pure nickel in electron tubes. They conserve critical material . . . reduce costs substantially. Supplied in annealed coils ready for your production.



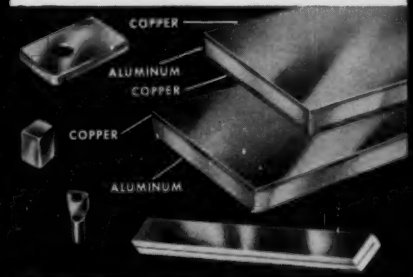
CLAD PRECIOUS METAL CONNECTOR MATERIALS

High reliability of connectors, clips, terminals obtained by using gold and other precious metal alloy stripe materials . . . place high performance materials in the contact areas . . . cost-savings and improved performance over gold electroplated parts.



TIN CLAD METAL STRIP and other Semiconductor Clad Metals

A number of combinations of clad metals are available for use on base tabs, lead wires, whisker wires, base materials and enclosures in silicon and germanium diodes, transistors and germanium power transistors.

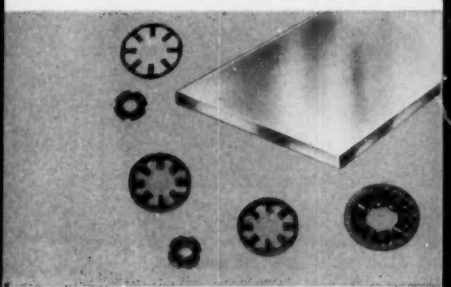


ALCUPLATE®

Easily formed, deep drawn or spun. Used for waveguides, component cases, variable condenser blades, chassis and electrical or thermal conductive parts. Light in weight, saves up to 30% over the cost of solid copper.

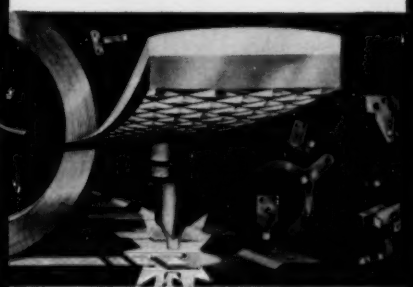
COPPER-CORED GLASS SEALING WIRES

Featuring a sound metallurgical bond, these wires give three times greater conductivity than solid 52 alloy wire of equal diameter . . . they facilitate miniaturization. Features include: leakproof seal between alloy and core, high electrical and thermal conductivity, lower costs.



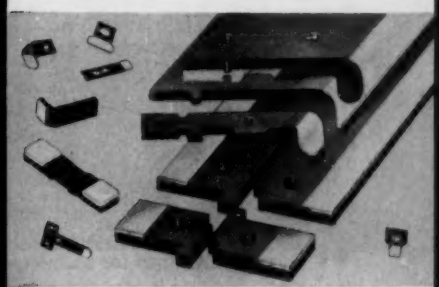
ALUMINUM-IRON ALLOYS

For magnetic applications requiring low core losses and high permeability at low flux densities in current and pulse transformers, relays, gyro mechanisms, servo mechanisms, missile guidance systems, etc.



CLAD ELECTRICAL CONTACT TAPES

For products you want to automate, this modern contact form permits greater latitude in contact assembly design . . . automatic assembly of two or more parts in a single operation. Tape contacts are easily attached by spot welding . . . are self-aligning . . . and allow broader assembly tolerances. Save up to 40% in contact costs.



CLAD CONTACT MATERIALS

Single and double inlay, overlay and toplay provide better electrical performance, longer operating life and lower fabrication costs. Complete assemblies can be made to close tolerances by single blanking and forming operations.

Circle 452 on Page 19

General Plate

Clad Metals and Clad

Electrical Contact Materials

Solve Design Problems...

Provide High

Performance Reliability

General Plate clad precious-to-base or base-to-base metals are inseparably bonded by a patented solid-phase bonding process without the use of brazing alloys or other intermediate material.

If you are seeking metals with useful characteristics that can't be found in a single metal or alloy, investigate clad metals. If you want stronger or lighter components — or better electrical and mechanical properties — or fewer corrosion problems — or if you are interested in conserving critical metals or reducing parts costs, you can profit by using General Plate Clad Metals.

Write for a General Plate Clad Base Metals catalog today. Or better yet, why not talk over your requirements with a competent field engineer? His knowledge of the applications of clad metals is yours for the asking. No obligation, of course.

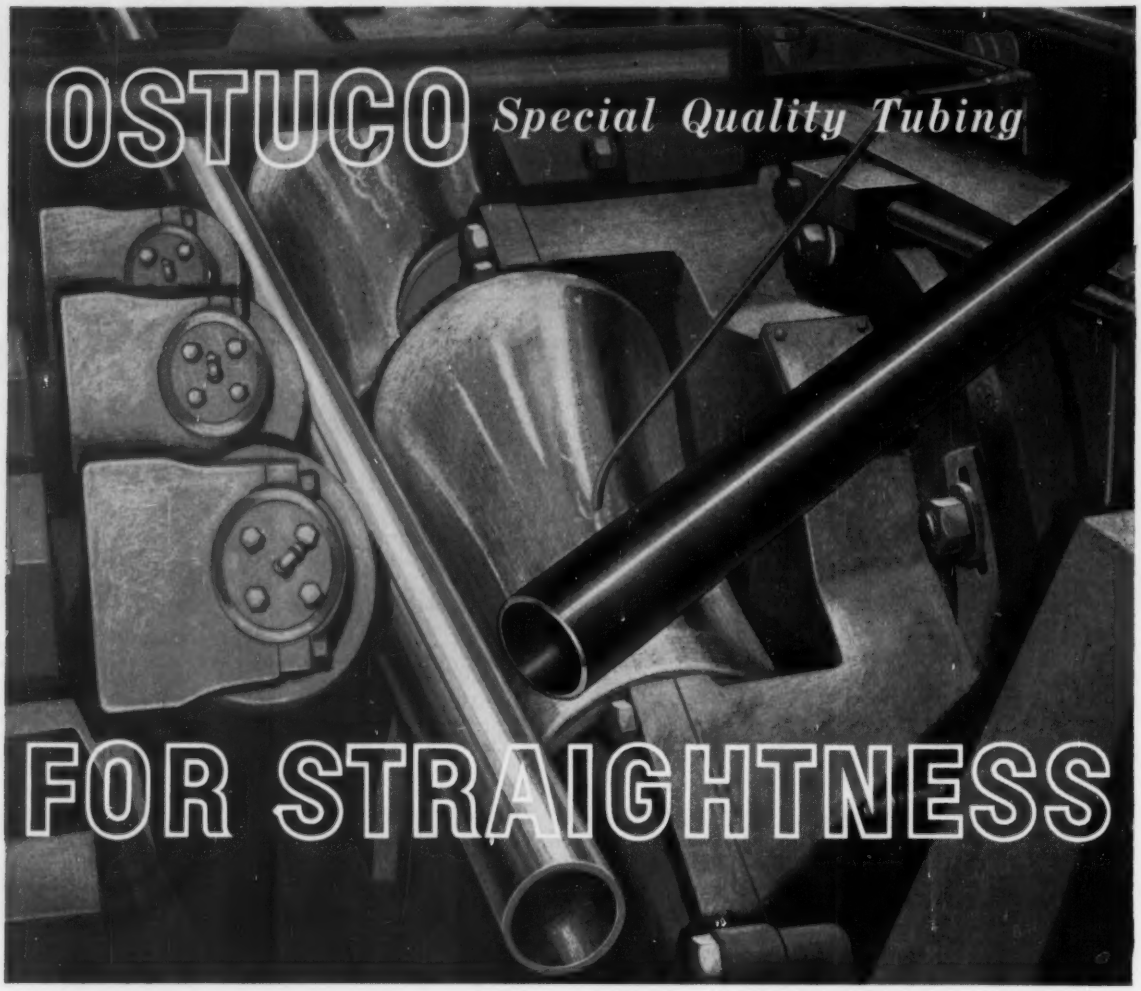
METALS & CONTROLS

808 FOREST STREET, ATTLEBORO, MASS., U.S.A.

A DIVISION OF TEXAS INSTRUMENTS INCORPORATED

GENERAL PLATE PRODUCTS: Clad Metals • Electrical Contacts • Truflex® Thermostat Metal
Platinum Metals • Reactor Metals • Radio Tube & Transistor Metals

Helicopter Manufacturer Specifies



Straightening Ostuco Special Quality Tubing to extremely close limits at Shelby mill.

"Our specifications for seamless steel tubing used in rotor drive shafts are tough to meet. In addition to stringent O.D., wall and concentricity tolerances, we require *special straightness* — tube after tube, shipment after shipment.

"Ohio Special Quality Tubing surpasses any other tubing we have ever used. We know this to be fact. Scrap and rejects are at a new low, inspection OK's and savings on this part are at a new high."

This actual case history may parallel your own product problems. For with Ohio Special Quality Tubing it's only the *quality that's special.* For further information contact our nearest sales office, listed in the Yellow Pages, or the plant at *Shelby, Ohio — Birthplace of the Seamless Steel Tube Industry in America.*

AA-9011

OSTUCO TUBING

OHIO SEAMLESS TUBE DIVISION

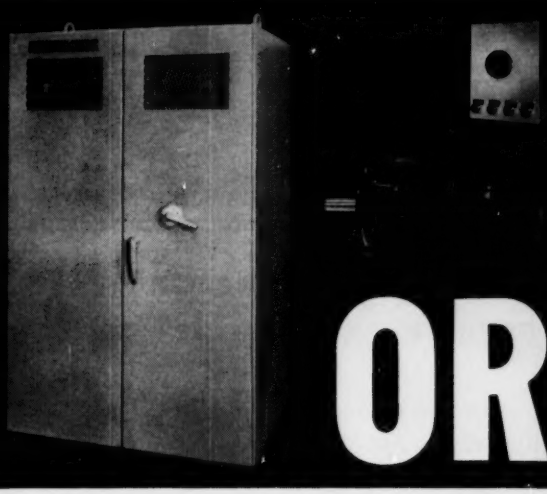
of Copperweld Steel Company • SHELBY, OHIO

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

SALES OFFICES: Birmingham, Charlotte, Chicago (Oak Park), Cleveland, Dayton, Denver, Detroit (Huntington Woods), Houston, Los Angeles (Lynwood), Moline, New Orleans (Chalmette), New York, North Kansas City, Philadelphia (Wynnewood), Pittsburgh, Rochester, St. Louis, St. Paul, St. Petersburgh, Salt Lake City, Seattle, Tulsa, Wichita CANADA: Railway & Power Engr. Corp., Ltd. EXPORT: Copperweld Steel International Company, 225 Broadway, New York 7, New York

GENERAL PLATE PRODUCTS: Clad Metals • Electrical Contacts • Truflex® Thermostat Metal
Platinum Metals • Reactor Metals • Radio Tube & Transistor Metals

YES



OR

Ten-second quiz for people who buy, operate or maintain electrical adjustable speed drives

YES	NO	
☐	☐	Adjustable speed drives should be simple to install, operate, and should require little or no maintenance.
☐	☐	Adjustable speed drives should offer a wide range with either constant torque or constant hp, and should offer smooth acceleration and deceleration.
☐	☐	Adjustable speed drives should offer high operating efficiency . . . and be adaptable to a wide range of motor sizes.
☐	☐	Adjustable speed drives should provide the required flexibility and inherent reliability for any type of application . . . intermittent or continuous.

If you have answered "yes" to the above questions, then you will be very much interested in obtaining complete information about the *all-new, static-powered* Westinghouse Adjustable Voltage Reactifier drive . . . (Type AVR). This new drive not only meets all of the above requirements, but also gives you many other advantages to perform a better job at lower cost. Ask your Westinghouse sales engineer to show you exactly where and how this new drive can benefit you. Or, write to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

J-22104

YOU CAN BE SURE... IF IT'S Westinghouse

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV MONDAYS

Circle 454 on Page 19

SERVICE AVAILABILITY IS ANOTHER MAJOR REASON WHY OEM DESIGNERS SPECIFY BELLOWS AIR MOTORS

In your products, as in ours, service to customers is an important selling tool. When you specify Bellows Air Motors and other Bellows pneumatic devices and controls as components in your machines—you know, wherever the machine will be shipped, there will be a Bellows Field Engineer nearby.

Over 150 full time, fully trained Bellows Field Engineers, in every important industrial area in the United States and Canada, in Great Britain, in Europe, and Australia are available to give quick, efficient and friendly help if it's needed. And seven manufacturing and assembly plants in the States, in Canada, in Great Britain and Europe safeguard your customers from "down time" due to "parts" delays.

Add to "service availability" the design and cost advantages this unique air cylinder with the built-in valve offers you: compactness, speed, precision-control and low cost—and it's easy to see why the Bellows Air Motor ranks first with design engineers.

This booklet tells the story
"The Place of the Bellows Air Motor in Original Equipment Design" tells in 14 quick-reading pages how the Bellows Air Motor can fit into your program. Free on request. Address Dept. MD-859, The Bellows Co., Akron 9, Ohio.

The Bellows Co.

DIVISION INTERNATIONAL BASIC ECONOMY CORPORATION

AKRON 9, OHIO

1029-B

Circle 455 on Page 19

Some Ideas

for your file of practical information on drafting and reproduction from

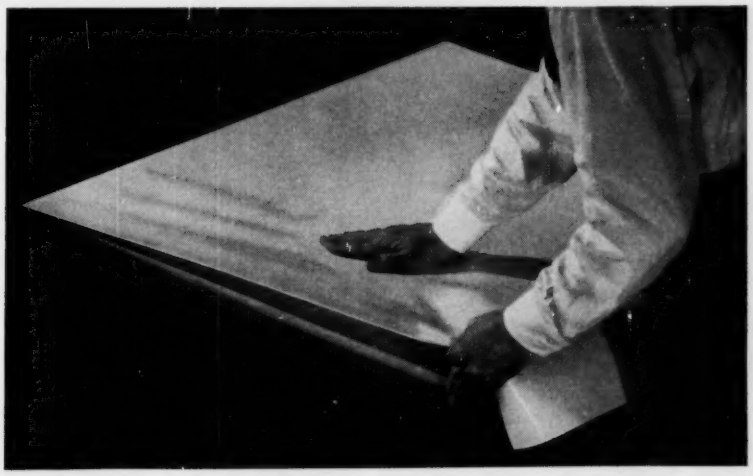
KEUFFEL & ESSER CO.

Frankly, we hope you're a fusspot. If you are fussy about the way you work, and proud of it, we think you'll enjoy knowing about three K&E items which reduce the effort required to get pin-neat results. Our first suggestion is . . .

A Better "Mattress" for Your Drawing Board

For effortless drafting, a good board cover is about as important as a good mattress is for sound sleep. Which is why so many draftsmen swear by LAMINENE® (N 70), the only *laminated* board cover material made. An exclusive, patented K&E process gives LAMINENE several very practical advantages over plastic coated papers. You can stretch it, drumhead-tight, over your board. All you do is wet the back, then secure the ends by taping or stapling to the underside of the board. After drying, LAMINENE grips the board as if cemented—there's no rippling, no stretching with the weather, no slack to take up. Its "drafting feel" is perfect: just the right balance of firmness and resiliency. LAMINENE'S non-glare surface makes it easier on the eyes, too, even under fluorescent lighting. You can expect to leave the board feeling fresher, even after a long day.

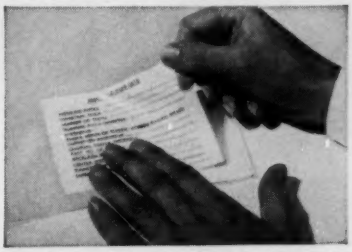
What's more, LAMINENE won't crack or scar like a plastic coating. Its laminated film surface is flexible, and stays that way—no crevices form to pick up workaday grime. It's easier to clean, too. A little soap and water is all it takes to keep LAMINENE looking like new.



LAMINENE is available in White or Eye-Ease Green; plain or with 4 x 4, 8 x 8 and 10 x 10 grids to the inch, which act as permanent two-way tracing guides. A free sample can be yours in a few days if you write us today. If you've never tried a laminated board cover, we promise you a new experience!

Stickers With Delayed Action

Want to eliminate a time-consuming chore? You can cut down on tedious repetitive lettering by having title blocks, specifications, and other symbols or legends printed



—clearly and sharply—on DULSEAL™ (74). This tissue-thin film has a delayed-action adhesive on the back, and a dull-finish face for easy writing or printing. Stickers made of Dulseal can be firmly positioned—and re-positioned hours later, just as firmly. The adhesive takes 24 hours to set. Once it does set, a permanent bond is formed with the paper or cloth beneath. Dulseal is chemically stable, and the adhesive will not bleed, even in hot copying machines.

Repeated erasures on Dulseal will not affect its "take." Produced by an exclusive process, the "tooth" is *built into* the surface. Transparent and low in reflectivity, Dulseal stickers will not affect the transparency or printing speed of your drafting medium. K&E supplies Dulseal in sheets, rolls (printed to your specifications if you wish), and as a mending tape in a handy dispenser. Try a sample, on us!

3 To Keep Clean

Best way to keep your tracings clean: don't let them get dirty. A mighty easy way to achieve this is to sprinkle the tracing lightly with gum eraser particles, while working. Then, triangles, T-squares, and scales stay clean, and clean the surface *automatically*, as they are moved back and forth. The particles will not dry out or harden—they contain no grit or abrasives. They'll actually improve the ink taking qualities of your drafting surface.

For this purpose, K&E supplies cleaning particles put up in three different ways. We think the new plastic squeeze-bottle (3036C) is the handiest of all. The shaker-top can (3036) has also been a drafting-room favorite for some time. And, for double-duty cleaning, we suggest the ABC Dry-Clean Pad™ (3037), which holds slightly coarser granules that sift through soft mesh. The ABC Pad also comes in handy for wiping a complete tracing after it is finished, or for preparing certain surfaces for ink work. Or for an overall pre-cleaning, since the best way to insure clean tracings is never to let soil build up.

The proverbial ounce of prevention is worth the traditional pound of cure!

These K&E products, and others that can make life easier for you, are available from your nearby K&E dealer. See him soon . . . or send us the coupon below for further information and samples.

KEUFFEL & ESSER CO., Dept. MD-8, Hoboken, N. J.

Please send me samples of LAMINENE® Drawing Board Surface Material, and DULSEAL™ Tape . . . plus information on K&E cleaning powders.

Name & Title_____

Company & Address_____

_____

2002

Circle 456 on Page 19

SMOOTH, "CUSHION" START

with new Century Electric part-winding start motor

This new motor . . . at either 1200 or 1800 rpm's . . . will give you smooth, "cushion" acceleration. No cogging, jerking or jarring equipment. No sub-synchronous stalling. Just dependable torque with the same 40% reduction in starting current of all Century Electric part-winding motors.

New winding—A special winding scheme makes this extra smooth start possible. Special cross connections are made between coil groups of the basic motor winding. Result: balanced stator field on first step position . . . no cogging . . . smooth acceleration. Means that now motors will give better performance on part-winding start. Also, more time can be taken for acceleration because the winding does not go "across the line" until the rotor has reached a higher speed.

Applications—Have an application where power company restrictions limit in-rush current? The complete line of Century Electric part-winding start motors is the answer. They provide the most economical and dependable way of starting equipment with low-starting torque such as fans, blowers, centrifugal pumps, and compressors, as well as reciprocating compressors equipped with unloading valves. And with new Century Electric part-winding motors heavier loads than ever before can now be brought smoothly up to speed.

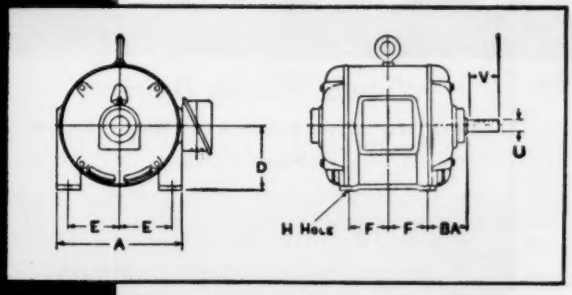
Construction—Century Electric part-winding start motors are available in approximate range of 20 to 150 hp sizes and in speeds of 1200 and 1800 rpm. They all have the high quality construction features of all Century Electric squirrel cage induction motors . . . coils are insulated with tough polyvinyl acetal resin . . . windings are dipped and baked with several coats of high temperature synthetic varnish which protect against oil fumes, mild acids and dust and grit . . . rotors are dynamically balanced so that motors run with extreme quietness and smoothness . . . rugged cast iron frame construction assures long life and low noise level.

Application aid—A Century Electric application engineer will be glad to discuss your part-winding start problems with you. Century Electric also makes a complete line of motors . . . all sizes and types from 1/20 to 400 hp. For a copy of the new Century Electric Motor Application Guide, please write for bulletin 270A.

CENTURY ELECTRIC COMPANY

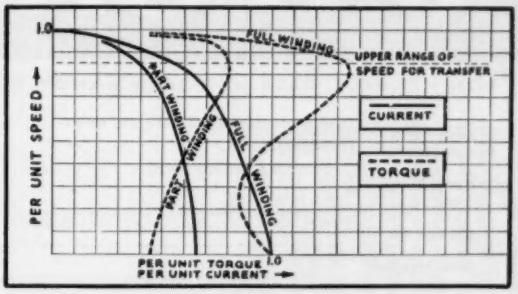
St. Louis 3, Missouri *Offices and Stock Points in Principal Cities*

Century 59-10



TYPICAL 30 HP part-winding start motor dimensions

Frame Size	Key	A	BA	D	E	F	H	U	V
SC 326U	½ x ½	16	5¼	8	6¼	6	21/32	1⅛	5⅜



SPEED-TORQUE curves show how transfer to full winding can be made at higher speed after current has fallen off.

Circle 457 on Page 19

BISHOP
Tubular Products NEWS

"METALS FOR PRECISION AND PERFORMANCE"

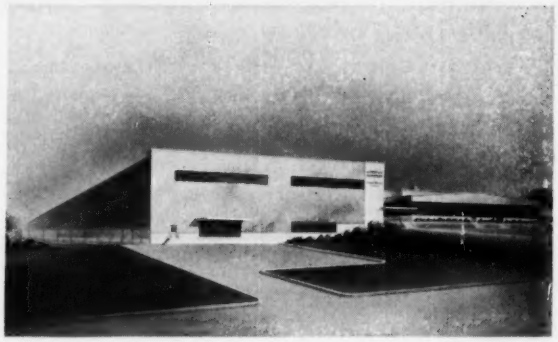
GOLD-CLAD STAINLESS TUBING CURBS CORROSION IN REACTOR

Photo pictures insertion of gold-clad stainless steel heat exchanger into gold-clad power reactor at AEC's Los Alamos Scientific Laboratory. Completely successful in recent operational tests, the unique reactor is designed to produce superheated steam in a single pass. This is the second experimental reactor using uranyl phosphate fuel—the first unit failed because of excessive corrosion in the heat exchanger. Gold-cladding now protects all structural parts in contact with the extremely corrosive solution.

Will clad metals solve *your* corrosion problems? Investigate the BISHOP line of clad metals. BISHOP was the first company to successfully produce gold-clad stainless tubing . . . coupon brings data. Use it.

Circle 458 on Page 19

NEW BISHOP TUBE MILL OPENS



Sketch shows new BISHOP facilities adjacent to the present tube mill in East Whiteland Township, west of Paoli, Penna.—completing the first stage in BISHOP's long range expansion program. This two-story structure will contain over 165,000 square feet of floor space. BISHOP platinum mechanical manufacturing operations also move to the East Whiteland plant.

Circle 459 on Page 19

BISHOP NOW DRAWING .002" WALL TANTALUM TUBING

Tantalum tubing with paper-thin wall thicknesses is now being supplied by BISHOP on special order. Sizes range from .062 in. OD x .002 in. wall to 1.5 in. OD x .125 in. wall. Columbium (niobium) tubing down to .002 in. wall has been produced and is also available. Can tubing of these "exotic" metals be the answer to any of your design problems? Check with BISHOP . . . use the coupon.

Circle 460 on Page 19

J. BISHOP & CO.
platinum works

FOR HELPFUL DATA USE THIS HANDY COUPON

- ☐ Tubular Products Bulletin No. 12
- ☐ Platinum Products Catalog No. 4
- ☐ Clad Metal Data
- ☐ Special Tubing Data

Check information you'd like and mail to
J. BISHOP & CO.,
45 King St., Malvern, Penna.

Name

Position

Company

Address

City Zone State

Tubular Products Division

45 KING STREET, MALVERN, PENNA.

NIagara 4-3100

THIS IS THE BISHOP LINE:
Products of all the Platinum Metals...
Small diameter Stainless Steel,
nickel and special alloy tubing

RELIABLE MULTI-PURPOSE "K" SERIES

cam-8-k

K STANDARD

FOR AIRCRAFT, ELECTRONIC, INSTRUMENT, MILITARY, MISSILE, INDUSTRIAL AND COMMERCIAL APPLICATIONS

Standard K and RK ., in straight and angle 90° plugs with wall mounting receptacles. Conduit and clamp entry types. 1 to 110 contacts in 250 different insert arrangements. 10, 15, 30, 40, 60, 80, 115 and 200 amp. silver plated brass on copper contacts. High quality phenolic, melamine, and formica insulators. Cadmium-plated aluminum alloy shells. Flashover voltages: 110 to 5000V, 60 cps ac rms.

KH-RKH

FOR USE UNDER CRITICAL PRESSURE AND LEAKAGE CONDITIONS—Hermetically sealed plugs with steel shells, steel contacts, and Canseal glass insulators for true hermetic sealing. Electro tin plating over cadmium plate over copper flash provides highly receptive surface for soldering and corrosion resistance.

RK

FOR FLUSH OR SEMI-FLUSH MOUNTING—Cannon RK Plug assemblies are equipped with an external threaded coupling nut which is the reverse of the standard K Series. Note: RK will mate only with RK's.

TBF-K

FOR CARRYING CIRCUITS THROUGH BULKHEADS

Cannon TBF-K Bulkhead Plugs feature a double-faced construction allowing mating at both ends. Pin inserts. Single piece shell.

RLKL-LKL

FOR TV AND OTHER PANEL SWITCHING OPERATIONS—Quick connect and disconnect RLKL Plugs are designed for one-hand fast disconnect use on TV station program switching panels and similar type operations. Feature a quick coupling means. Latch-lock secures plug to mated fitting (RLKL receptacle). Thumb pressure releases it.

FW-K FWR-K

FOR OPEN FLAME PROTECTION AGAINST HIGH TEMPERATURES—Cannon K Firewall Plugs are available in straight and angle 90° shell types. Wall mounting receptacles also available. Phenolic or fireproof inserts of glass-filled materials. Crimp type contacts. Cannon originated the firewall connector and continues to be the leader in this important field.

SK-M7-21C

FOR USE IN TELEPHONE "BEEPER" AND SIMILAR APPLICATIONS—Widely used on telephone recording units known as "beepers." Adaptable for other similar applications.

K ACCESSORIES—Cannon K Series Accessories include Straight and Angle 90° Junction Shells, Dust Caps, Bonding Rings, Gland Nuts, Clamps, and Dummy Receptacles to hold and protect plugs when not in use.

Cannon has available a wide variety of other Plug designs FOR EVERY CONCEIVABLE APPLICATION...including aircraft and electronic Plugs conforming to Specification MIL-C-5015D; Unit-Plug-In Rack/Panel and Modular; Audio and Low-Level Circuit Plugs; Miniature and Sub-Miniatures; Coaxial RF Series Plugs, Printed Circuit Plugs; GM Plugs and Cannon Plug/Harness Systems: "Kwik-Term" Terminals and DC Solenoids.

FOR ADDITIONAL INFORMATION on the typical designs illustrated...other configurations for your specific applications...or the design, engineering and manufacture to your special needs...write to **Cannon Electric Company**—3208 Humboldt Street, Los Angeles 31, California. Please refer to Dept. 185.

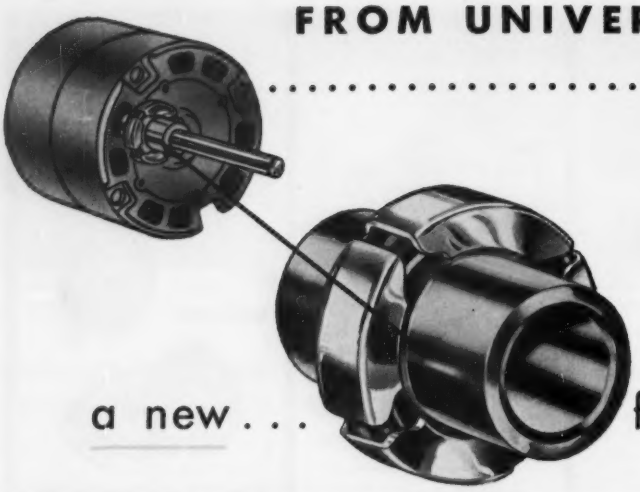
LARGEST FACILITY IN THE WORLD FOR PLUG RESEARCH-DEVELOPMENT-MANUFACTURE

CANNON PLUGS

Factories in Los Angeles, Santa Ana, Salem, Toronto, London, Paris, Melbourne, and Tokyo. Distributors and Representatives in the Principal Cities of the World.

Circle 461 on Page 19

FROM UNIVERSAL ELECTRIC



THE UNIVERSAL BEARING*

a new . . . free aligning bearing

*PATENT APPLIED FOR

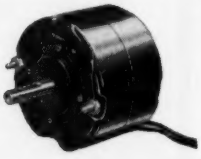
A new revolutionary bearing assembly, the **Universal Bearing**, that promises to eliminate fractional hp motor bearing problems has been designed and is now a feature of UNIVERSAL ELECTRIC motors. The new **Universal Bearing** does not rely on spring tension to aid its alignment but utilizes only the shaft itself. This is accomplished by moving the axis of support from the end of the bearing to the center . . . the ideal location.

Flexibility and rigidity of bearing support and bearing are of primary importance, particularly in fractional hp motors. The design of the **Universal Bearing** insures continuous and positive alignment to the shaft at all times. A neoprene collar, which is flexible, provides a perfect and firm fit between bearing and bearing support surface. The **Universal Bearing** is inherently in balance . . . and cannot get out of either alignment or balance. It is as firm as a rigid bearing; more flexible than a self aligning bearing.

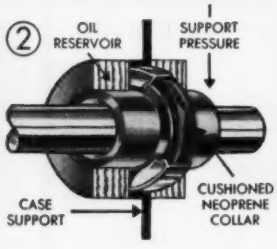
The **Universal Bearing** Assembly provides longer bearing life, better lubrication and an easier starting motor that runs without a whisper of sound. This is the first major bearing improvement since UNIVERSAL introduced the coil spring bearing retainer in 1944.

TYPE 23
1/50 to 1/12 H.P.

These are the first two UNIVERSAL ELECTRIC motors to feature the revolutionary, new **Universal Bearing.**



TYPE 118
1/200 to 1/50 H.P.



The new **Universal Bearing** is so designed that support pressure is on the center of the bearing, rather than on the end. This eliminates the uneven tension common in the spring and permits adjustment of the axis position to *true* alignment. The bearing is inherently in balance and can adjust to any shaft misalignment 100% of the time under any load conditions. A neoprene collar is used around the outside surface of the bearing to accommodate manufacturing tolerances. Small metal clips are fitted around the outside surface to confine the neoprene collar and allow a free sliding movement along the bearing support surface. The neoprene collar expands or contracts within the metal clips to afford a perfect mating surface.

50-A

UNIVERSAL ELECTRIC COMPANY

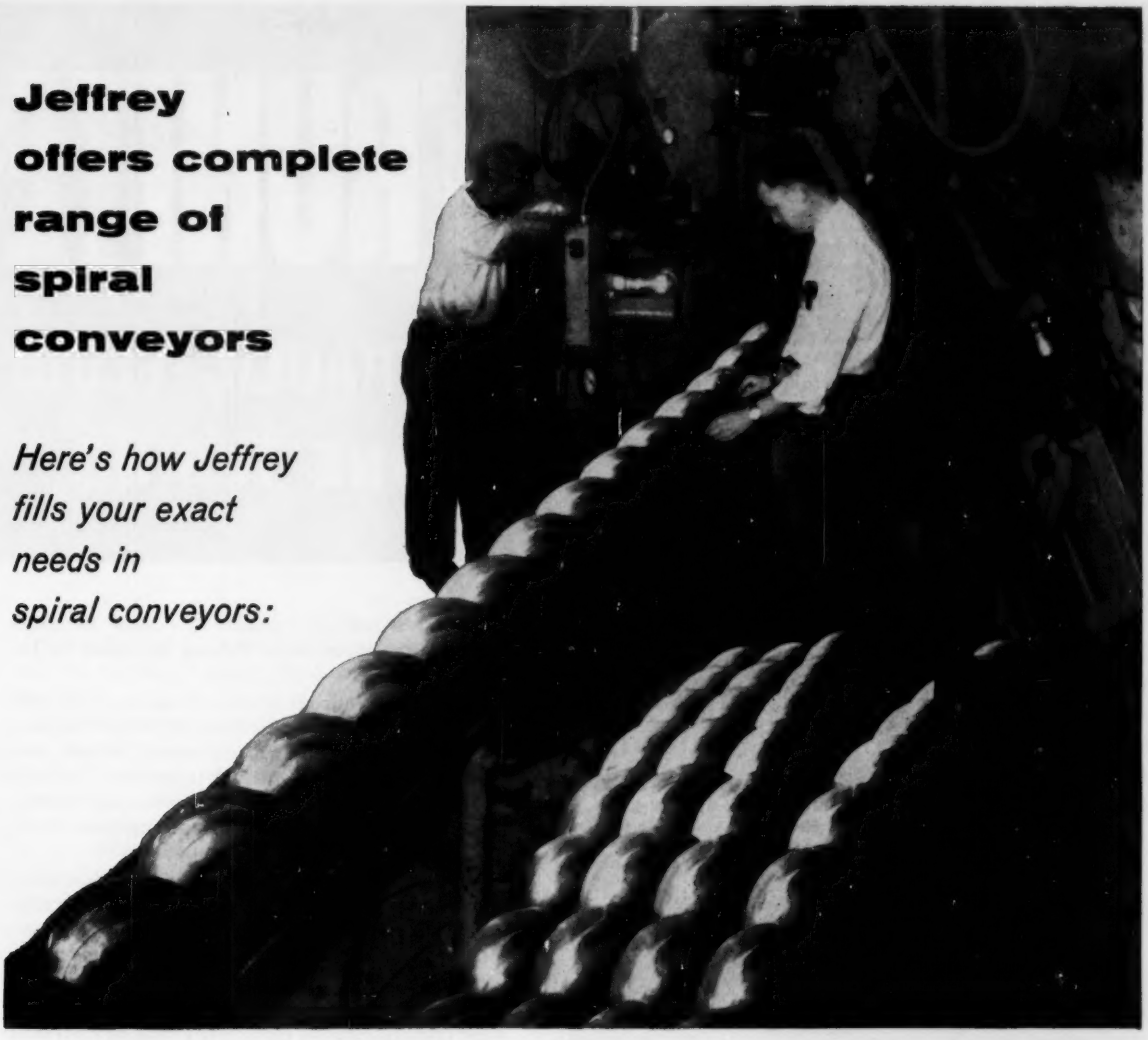
PRECISION ELECTRIC MOTORS

EXECUTIVE AND GENERAL SALES OFFICES: OWOSSO, MICHIGAN, DEPT. 10

Circle 462 on Page 19

Jeffrey offers complete range of spiral conveyors

Here's how Jeffrey fills your exact needs in spiral conveyors:



- Complete range of types—sectional spirals, ribbon conveyors, cut flight conveyors, short pitch conveyors, double flight conveyors—all in a wide range of diameters and thicknesses.
- Stock is maintained on all widely used types, permitting Jeffrey to make fast shipment.

Standard conveyors are made in mild or abrasive resistant steels. Where heat-resistance or corrosion-resistance is required, you can select Jeffrey spirals in stainless steel, brass, Monel, aluminum, or other special metals.

With Jeffrey spiral conveyors you get a complete selection *plus* extras in quality—precision fit, smooth flight surfaces and non-toxic protective coating. For full information write for Catalog 951. The Jeffrey Manufacturing Company, 798 North Fourth Street, Columbus 16, Ohio.

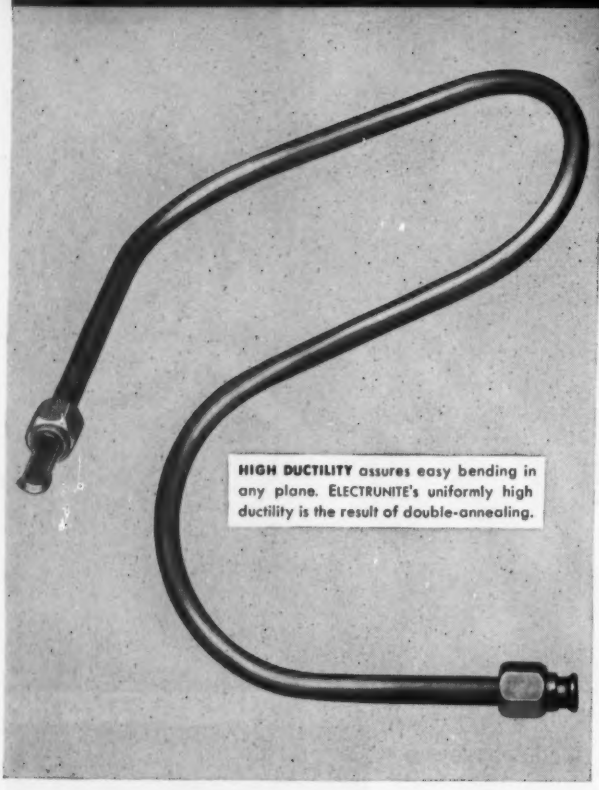
Centrifuge cake ranging from 62 to 67 per cent solids are transferred to a mixer by a 16" diameter Jeffrey Spiral Conveyor at the lime reclaiming plant of the City of Lansing, Michigan.

JEFFREY

CONVEYING • PROCESSING • MINING EQUIPMENT...TRANSMISSION MACHINERY...CONTRACT MANUFACTURING

Join the Big Switch to Republic ELECTRUNITE

HYDRAULIC FLUID LINE TUBING



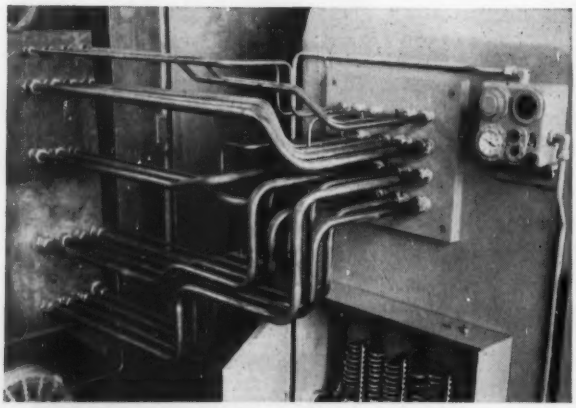
HIGH DUCTILITY assures easy bending in any plane. ELECTRUNITE's uniformly high ductility is the result of double-annealing.

Get more tube per dollar . . . Now Electric Resistance Weld Steel Tubing included in JIC Standards . . .

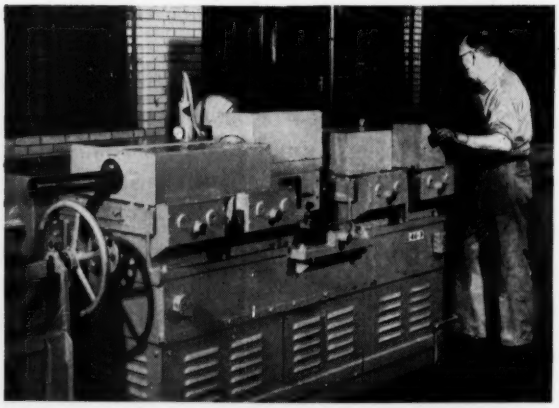
Join the hundreds of manufacturers using millions of feet of Republic ELECTRUNITE® Hydraulic Fluid Line Tubing. As a result of their own tests, many equipment and machinery builders and their maintenance departments switched to this quality-proved hydraulic tubing prior to its being included in the JIC Standard.

Like them, you'll get *more tube per dollar* when you specify Republic ELECTRUNITE Hydraulic Fluid Line Tubing. But initial cost savings are only part of the story. *Savings in downtime* reflect even greater cost reductions!

ELECTRUNITE—produced by the world's largest manufacturer of electrically welded hydraulic tubing—is made from flat-rolled steel. *Prime* steel—checked for defects as only flat-rolled steel can be checked. Then: formed, welded, annealed,



READILY ASSEMBLED—close dimensional tolerances maintained in the drawing of ELECTRUNITE Hydraulic Fluid Line Tubing assure lower-cost installation.



QUALITY YOU CAN MEASURE! Specify FARROWTEST® non-destructive electronic testing to MIL-T-17188 or ASTM-A-178 for extremely critical applications. Offered as an alternate to hydrostatic testing.

ELECTRUNITE IS EASILY FLARED AND BENT BACK upon itself to accommodate standard or flare-type fittings.

cold-worked, and annealed again into a tube of *prime* quality . . . a tube that meets or exceeds the normal life of tubing produced by any other method.

ELECTRUNITE'S uniform walls and concentricity, coupled with uniformly high ductility, assure better bending and flaring characteristics. In the *history* of ELECTRUNITE Hydraulic Fluid Line Tubing, no failure resulting from longitudinal or transverse cracks has been reported.

You'll find that ELECTRUNITE Fluid Line Tubing is available in all the sizes shown in the *JIC Standards Book.* Also available in an even wider range of sizes produced to our specification HL-1 (which meets all test requirements of the JIC Standard).

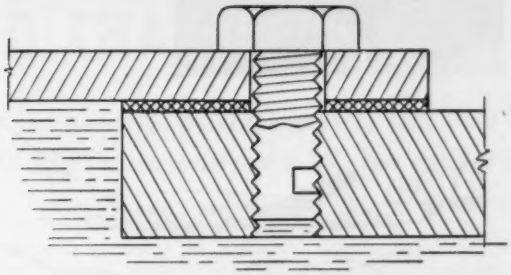
Investigate ELECTRUNITE'S many cost-reducing features. Contact your ELECTRUNITE sales representative or mail the coupon for complete information, including a copy of specifications.

AVAILABLE IN ALL SIZES SHOWN IN JIC STANDARDS BOOK. AVAILABLE IN A WIDER RANGE OF SIZES PRODUCED TO OUR SPECIFICATION HL-1 (WHICH MEETS ALL TEST REQUIREMENTS OF THE JIC STANDARD).

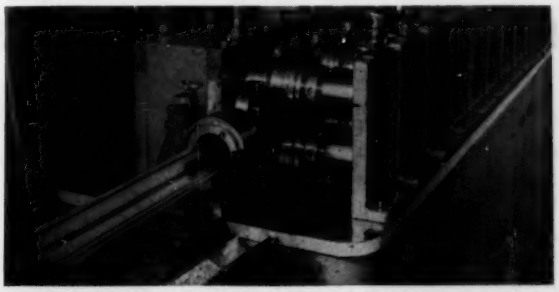
REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

STAINLESS STEEL TUBING CUT COSTS for Cleveland Process Company, makers of immersion heaters. Brittle material originally used for casing of heating element was expensive, often cracked when scale was removed. Cleveland Process Company solved the problem by switching to Republic Stainless Steel Tubing. ELECTRUNITE Stainless Tubing is strong, easy to fabricate, will save money in the long run. Send for more information.



LIQUID SEALING PERFORMANCE is an added feature with Republic Self-Locking Nylok® Bolts. Nylon pellet in compression tends to expand, effectively closing the space between non-loadbearing surfaces of mating threads. Fluid escape along helical thread path is blocked. Nylon pellet resists aging, moisture, and ordinary solvents. Send coupon for full information.



SAVE PAINT PREPARATION COSTS on your formed steel products by specifying Republic Electro Paintlok®. Special paint-holding surface applied at our mills won't crack, flake, or peel—even under severe bending—as demonstrated by this acoustical panel forming operation. Final finish can be applied immediately, with excellent results. Mail coupon for complete information.

REPUBLIC STEEL CORPORATION
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Please send more information on:

☐ ELECTRUNITE Hydraulic Fluid Line Tubing, including a copy of specifications
☐ Stainless Steel Tubing ☐ Self-Locking Nylok Bolts
☐ Republic Electro Paintlok

Name_____ Title_____
Company_____
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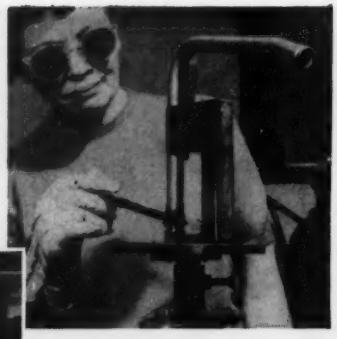
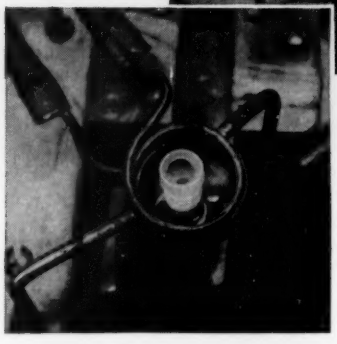
B-1 Flux is particularly effective in removing refractory oxides such as those formed in stainless steels.

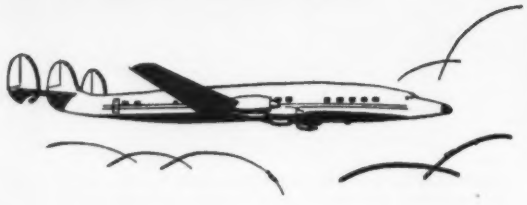


Operator fits preformed ring of BRAZE 541 prior to fluxing. This is a hose and tube assembly for an oil line.

Here operator applies gas-air torch, hand-feeding BRAZE 541 to joint.



Oil-bearing unit under induction heating.



Here's How Stainless Steel Fuel Systems Benefit From

HANDY & HARMAN SILVER BRAZING

Tube Processing Corporation, Indianapolis, Indiana, makes aircraft and missile fuel systems and, if anything has to be more failure-proof than a fuel line assembly in an airplane, you name it. The units shown here are made of 410 stainless steel tube and 321 stainless steel fittings; when they're joined, they must be joined permanently. Exhaustive tests, including X-ray, pass on each assembly before final acceptance.

Operator placing oil line (of another type) in induction heating ring.

To meet all requirements: strength, ductility, liquid and airtightness, production speed and economy, Tube Processing uses Handy & Harman's special alloy BRAZE 541 (formerly Alloy 4772) and HANDY B-1 FLUX.

Developed strictly for brazing stainless, BRAZE 541 is one of many Handy & Harman brazing alloys—both standard and special—made to do a specific job and do it better than any other metal-joining method.

Name your product and the metals it's made of, the chances are very good indeed that one of Handy & Harman's silver brazing alloys can join it better than the method you now employ. Better from every aspect: economy, speed, strength, conductivity, labor savings. Put your product in these pictures for the same benefits.

An exclusive additional benefit is Handy & Harman's application Engineering Service. This is a service that exists to show you how these benefits can best be applied to your product. We invite you to take advantage of both Handy & Harman Brazing Alloys and Engineering Service.

GET THE FACTS

Technical Bulletins T-1 and T-2 give the general characteristics of silver brazing alloys plus the compositions, melt and flow points of 32 separate alloys. Write for your copies.

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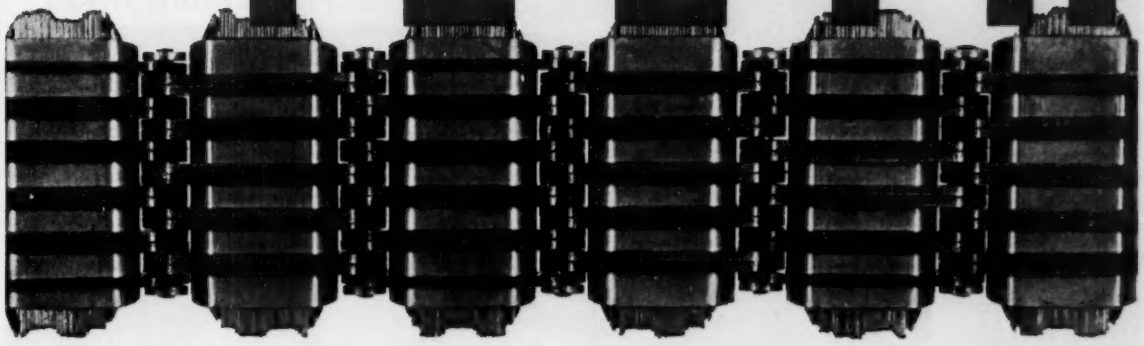
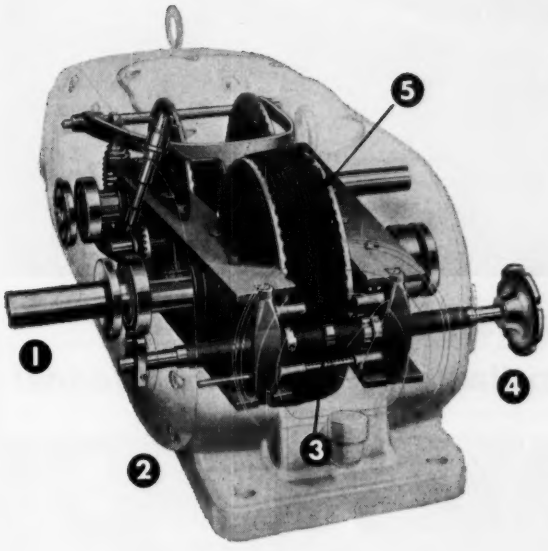
PUT TEETH



IN YOUR SPEED CHANGING JOBS



Get the positive, accurate control that only LINK-BELT's chain-driven P.I.V. can deliver

Yes, you put teeth into your speed changing jobs because Link-Belt P.I.V.—unlike other variable speed drives—utilizes an exclusive metal, self-tooth-forming chain.

Here's how it works! P.I.V. chain consists of a series of overlapping steel links. The links contain packs of slats which are free to move from side to side, singly or collectively, to serve as teeth. The chain meshes with radially grooved wheels, which are cut to a constant depth towards the wheel periphery. Beveled sides of the grooves offer gripping areas . . . provide a positive, nonslip contact at any speed, under all loads.

Makes changing speed simple too! A turn of the control screw simultaneously varies the effective diameters of the conically shaped wheels—closing one set, spreading the other. At the same time, the self-tooth-forming chain automatically adjusts to provide desired ratio between the input and output shafts.

BOOK 2274—Your Link-Belt office has Book 2274 on P.I.V. drives from ½ to 25 hp. Refer to the yellow pages of your local phone directory under Power Transmission Equipment.

(1) You can get minute speed changes and maintain them accurately while operating under full load.

(2) All-metal, totally enclosed—unaffected by atmospheric conditions. All vital operating parts splash-lubricated from a common housing reservoir.

(3) Easy-view speed indicator facilitates speed selection and adjustments to meet all requirements.

(4) An infinite number of positive, stepless speed adjustments may be made with manual, electric, pneumatic or hydraulic controls.

(5) Self-tooth-forming chain is made from a series of overlapping steel links. Links contain packs of hardened steel laminations or slats (shown above). Slats grip toothed wheels positively without slippage —give the speed you need at any setting.

15.242

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To serve Industry There Are Link-Belt Plants, Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.

LINK-BELT

P.I.V. VARIABLE SPEED DRIVE

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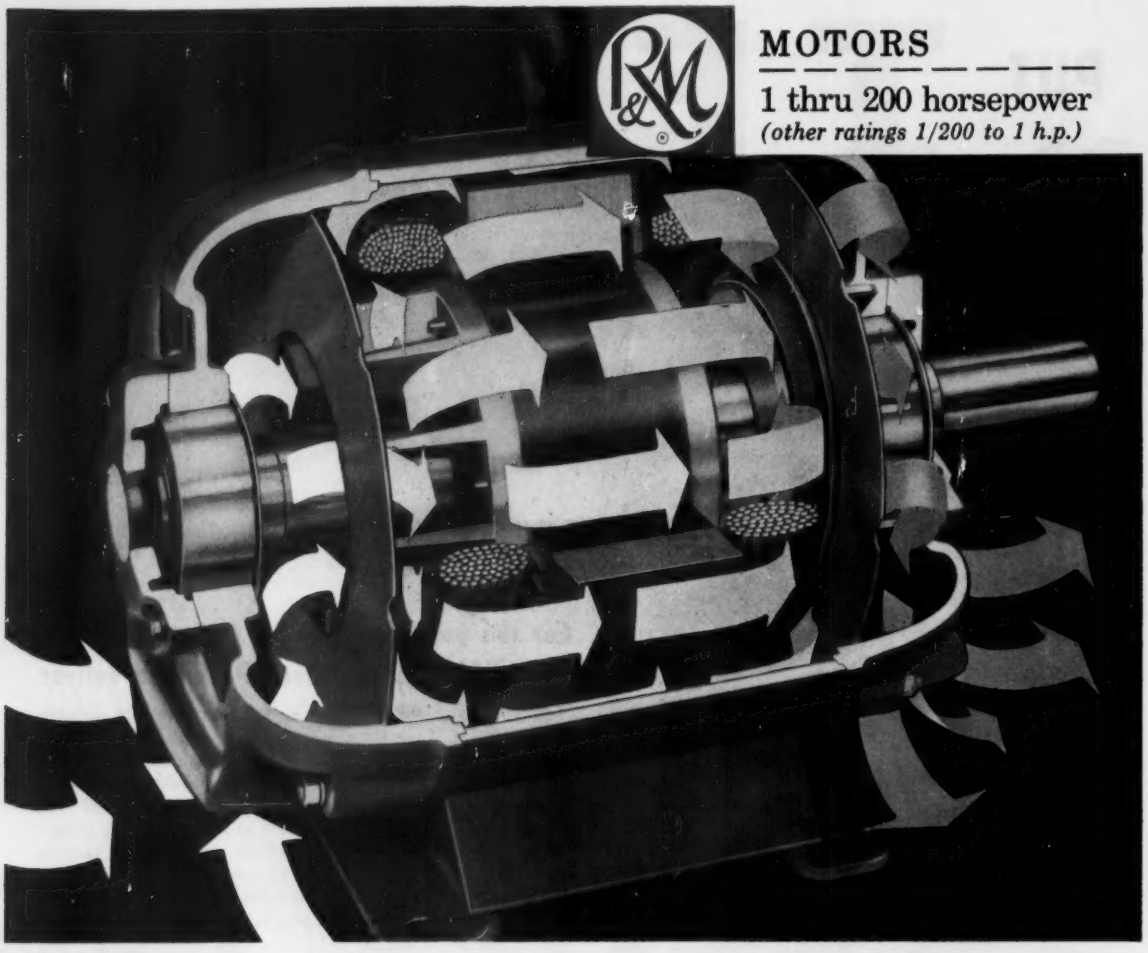
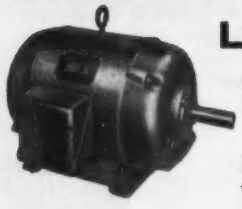


MOTORS

1 thru 200 horsepower
(other ratings 1/200 to 1 h.p.)

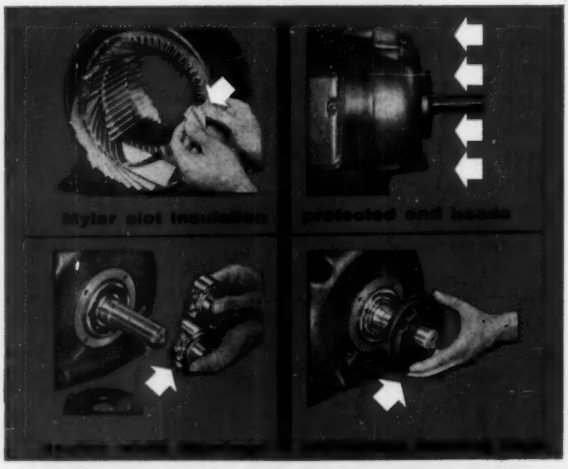


Longer Life because High Velocity *"Dual-Sweep"* ventilation *Cools and Cleans!*

ROBBINS & MYERS "Dual-Sweep" ventilation is a new concept in high velocity internal cooling and cleaning, designed to greatly prolong motor life. Tandem fans—one pushing, one pulling—create end-to-end ventilation that eliminates "dead" areas and converging air currents which deposit dirt. Venturi baffles at each end of the motor direct air in a washing action over and around end coils where it's most needed. Passages between field and outer shell form a "cylinder of air" which carries off motor heat.

R&M motors' long-life insurance also includes these features: Mylar* insulation that has 8 times the dielectric strength and 35 times more moisture resistance than ordinary paper insulation . . . double width bearings with extra-large grease capacity . . . end heads that offer full height protection . . . removable caps for quick bearing inspection and re-lubrication. For details, write today for Bulletin 520 MD .

**DuPont registered trademark*



ROBBINS & MYERS, INC.

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AVOID the
HIGH COST
and difficulty
of fabricating
long, hard
& straight parts
by conventional
methods . . .

THOMSON

60 Case

hardened and ground

SHAFTS, ROLLS, GUIDE RODS and other long-round parts

60 Case is the result of over ten years of experimental work and production experience with hardened and ground shafts which are a requirement for BALL BUSHINGS, the Linear Ball Bearing manufactured by Thomson Industries, Inc.

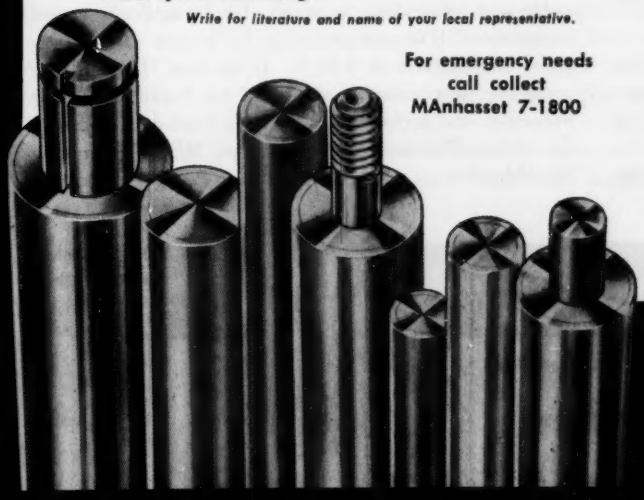
The special techniques and equipment that have been developed enable high production rates and low handling costs. This permits big savings over conventional methods which are plagued with erratic warpage, straightening and resultant grinding problems. Finished *60 Case* parts frequently cost less than the scrap losses that result from conventional methods.

60 Case material has a surface hardness close to 60 on the Rockwell C scale which is essential to resist wear.

Long lengths of material ranging in diameter from ¼" to 4" are stocked to enable prompt shipment of *60 Case* parts, with or without special machining.

Write for literature and name of your local representative.

For emergency needs call collect MAnhasset 7-1800



ADVANTAGES of *60 Case*

- COST REDUCTION
- HARD BEARING SURFACE
- ACCURATE DIAMETERS
- GROUND FINISH
- STRAIGHT PARTS
- DELIVERY FROM STOCK
- ADDED STRENGTH
- UNIFORM HIGH QUALITY

TYPICAL *60 Case* PARTS

GUIDE RODS, SHAFTING, ROLLS, TRAVERSE RAILS, PISTON RODS, ARBORS, LEADER PINS, TIE RODS, KING PINS, AXLES, CONTROL RODS, GUIDE POSTS, MANDRELS, BEARING ROLLERS, SPINDLES

THOMSON INDUSTRIES, Inc.
Dept. C-5, Manhasset, New York

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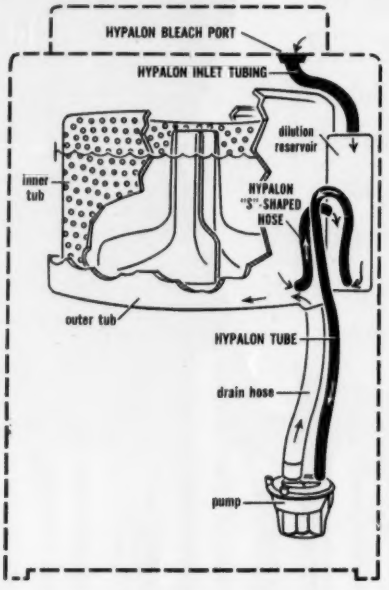

MAYTAG TIMED BLEACH INJECTOR. Concentrated chlorine-type bleach is poured through the bleach port into the dilution reservoir. Here it is diluted four times by water from the tub. Diluted bleach is metered to the pump, and then delivered to the washer's outer tub. Within four minutes after the wash cycle begins, bleach reaches optimum concentration in the tub.

Maytag finds HYPALON® immune to chlorine bleach at 158° F.

Maytag had a good idea for their All-Fabric automatic washer. Why not design a timed bleach injector to automatically dilute and meter liquid bleach into the wash water? Then the housewife would have to add bleach only once . . . when she loaded the machine. Bleaching would be safe for fabrics, and wouldn't destroy the optical brighteners in detergents.

But there was a problem. To do this, they'd need flexible hose and tubing that could safely handle chlorine-type liquid bleaches. Maytag engineers tested hoses of several materials in 5¼% hypochlorite solution at 158° F. All hoses except one suffered damage within 24 hours. The exception: a hose made of HYPALON, a Du Pont synthetic rubber. It remained unharmed even after a week's testing.

HYPALON was the solution—just as it has been for numerous other appliance design problems. For example, drain hose coated with HYPALON has proved to be color stable and impervious to ozone. On hermetically sealed compressors, HYPALON jacketing for lead-in wire has resisted temperatures to 350° F. To see how HYPALON can serve you, just write for a copy of our booklet outlining properties and performance. E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. MD-8, Wilmington 98, Delaware.

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SYNTHETIC RUBBER

NEOPRENE
HYPALON®
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ADIPRENE®

Better Things for Better Living . . . *through Chemistry*

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MACHINE DESIGN
August 6, 1959

The Royal Pleasure

THE business of business, so the saying goes, is to please people. And that's no trivial undertaking. A single business has to please many groups of people: Customers, employees, suppliers, stockholders, neighbors—not forgetting the government.

But unless one group—the customers—is pleased, there is scant prospect of pleasing any others, if the company is in a legitimate, competitive business.

Whether he buys consumer goods or industrial products, the customer is privileged to change his mind for any reason—or none. His mind can be changed by an ad, a salesman, hearsay, a particular experience, engineering design, or product appearance.

Of the factors that contribute to a pleasing appearance none involves more subjective reaction, is more governed by taste and whim, than color. We try to describe colors in terms of other senses. Colors are said to be warm, cold, exciting, restful—even nauseating. We even associate color and sex — virile colors and effeminate colors.

It has been found that brilliant colors appeal to people in the humbler walks of life, while subdued colors are more likely to please those at higher educational and income levels.

Where does all this leave the designer who is trying to choose colors for a sewing machine, a camera, or a lift truck? Ogden Nash once observed that "In the world of mules, there are no rules." The world of color is only slightly less disconcerting.

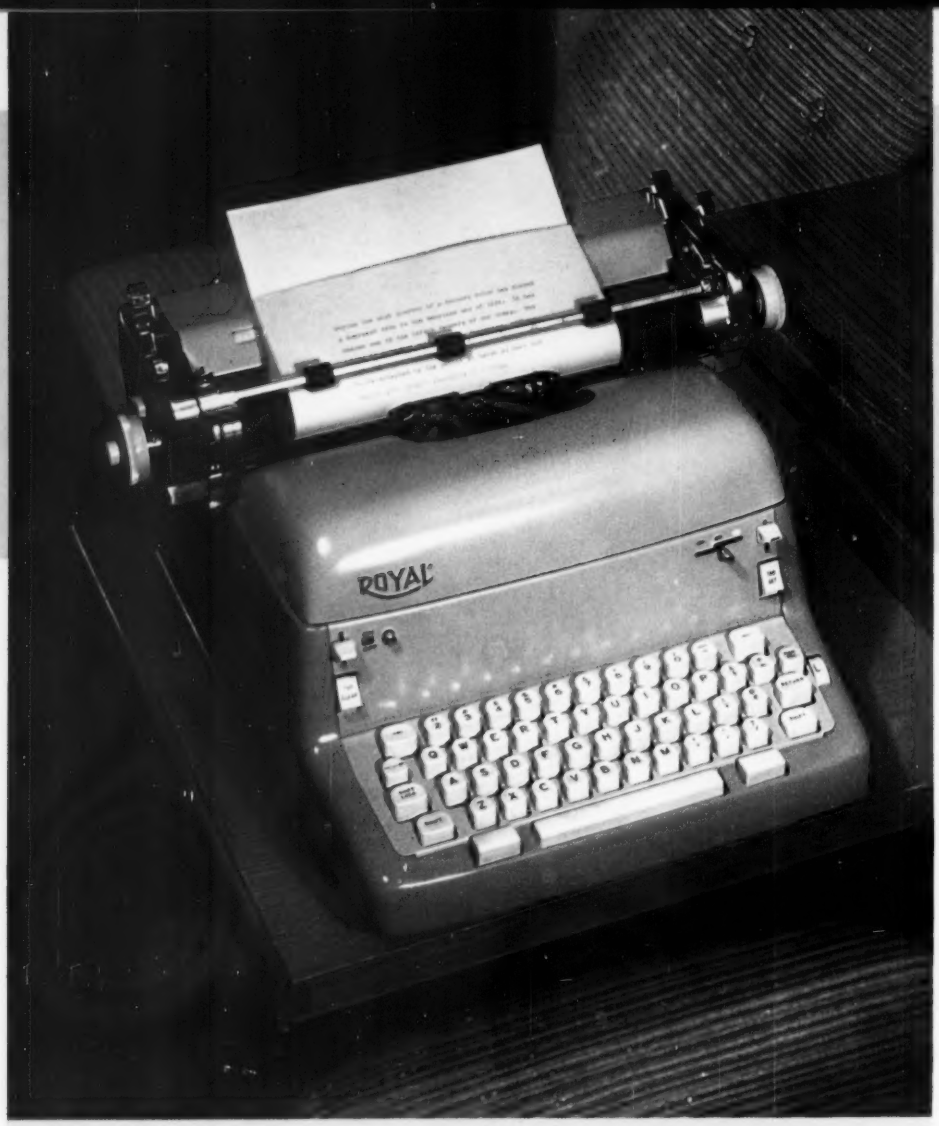
There are some guideposts, however. Faber Birren's article overleaf takes the reader on an exploration of that confusing, fascinating world of color. The hazards are many and things are seldom what they seem.

The designer's own taste—or even his wife's—is no sure guide. And there's a difference between what a customer says he likes, and what he actually buys.

Yes, the customer is king, all right, and pleasing royal whims has always been a tricky business.

Colin Carmichael

EDITOR



A functional approach to color was taken on this Royal office typewriter. The key area is held light in tone to assure comfortable and efficient seeing. There is minimum contrast between machine and white paper which obviates the need for constant eye adjustments.

Color likes and dislikes in America are continually undergoing change. Regardless of the utility and efficiency of a product, appearance factors are often vital in its acceptance. In virtually everything made today, from portable radios to automobiles or typewriters to passenger planes, there have been radical changes in color—mostly from the drab, dark colors of the past to a new and bright current trend.

The big problem with this constant change is how to standardize on production colors and yet remain in tune with color trends. The secret is standardizing on colors which are assured of volume acceptance. At the same time, these standards must be flexible enough to be adjusted to keep abreast with shifting human wants.

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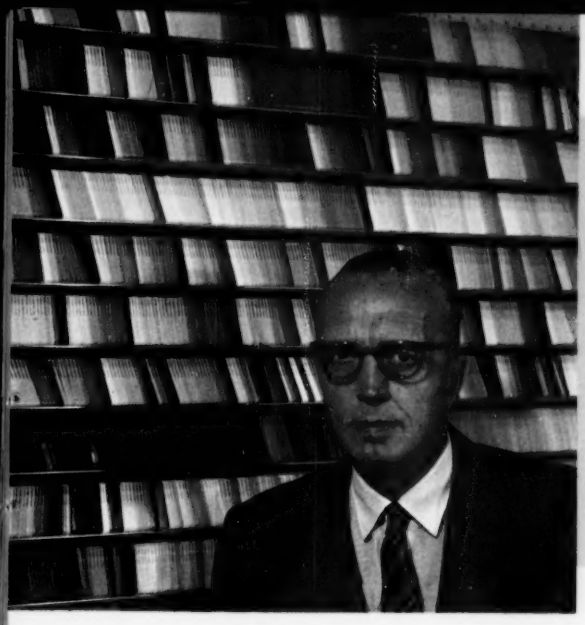


Faber Birren and his laboratory collection of plastic colors. He employs careful research methods to screen thousands of different hues and determine which particular few, at a particular time, are most acceptable. Mr. Birren, one of the best known color authorities in the United States, has authored sixteen books and several hundred articles for the general press and business magazines. As an independent consultant, he has operated his own research organization for over 20 years. Among his clients are such firms as Du Pont, General Electric, Hoover, House & Garden magazine, Minnesota Mining and Manufacturing Co., National Lead, Royal Typewriter, Ruberoid, West Virginia Pulp & Paper, and several others.

10 basic steps for improving product appearance and appeal by

choosing the right color

FABER BIRREN, President, American Color Trends, New York, N. Y.

NO PRODUCT is colorless. As long as the eye sees it, some emotional reaction will follow. Visual impressions are inescapable. At times the application of color is fairly practical; at other times it may be meaningless, except in terms of abstract appeal. Blue coal is an example of functionless color; so is red kerosene in southern markets. No matter what the product, color seems to add fascination and excitement.

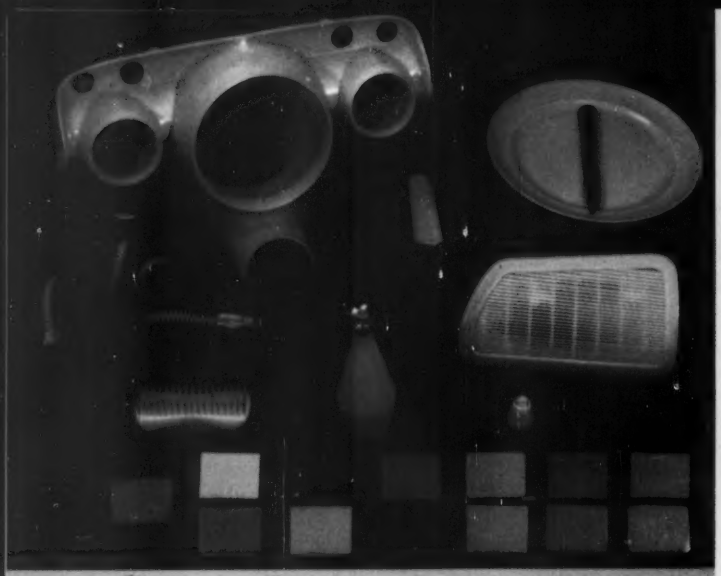
Because color is so much in the psychological realm, it becomes a complex medium to handle. Every human being is a self-appointed expert on color, for virtually everyone has strong feelings about it. Color choice is thus forever conditioned by personal convictions and predilections.

Color for the sake of color is never enough. Income and social status, for example, may affect choice. The masses of people are likely to want what everyone else has, whereas the true sophisticate will pursue individuality. This, perhaps, is the simple division of the national market for color. The sophisticates, about 10 per cent in number, will insist on having what no one else has. They are the true style leaders, and they will demand *many* colors. The rest of the population, however—the 90 per cent—will tend to follow the parade of fashion; they will, acting as a big group, want *few* colors and pretty much what everyone else has.

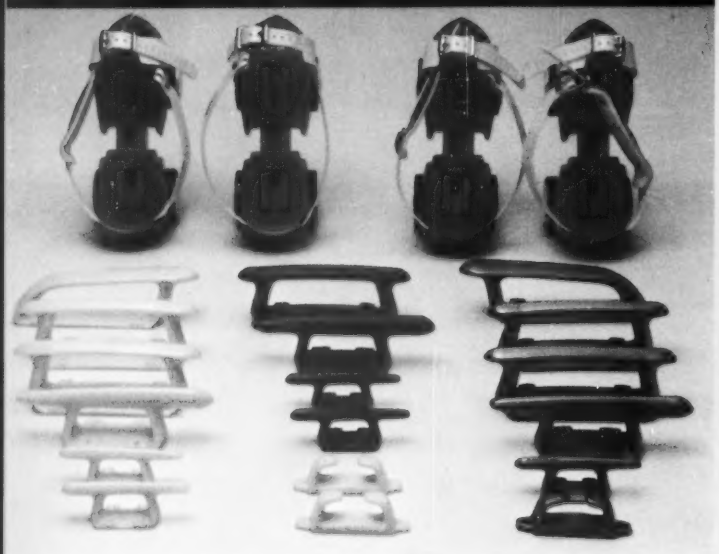
Yet even in the big group, there are so-called moderns and conservatives. If the moderns are likely to want the bold and exotic, the conservatives are likely to show more judgment and restraint. Any product designer must therefore find out which market he is to serve. If he designs something in which style rather than function is the chief appeal, he had better brush up on current fashions and fancies. If his product is a useful and practical one, he will do well to use color with sense and purpose. If what he designs must serve both classes, he should prepare himself to make allowances for alternate color effects which will appeal to both groups.

be careful of too much color subtlety

Many a product designer, thinking of his own educated taste, may be guilty of too much thought and too much subtlety. More often than not the color problem is quite elemental. In packaging research, a bright vermillion red has consistently



Extensive research into long-term color trends was an important factor in developing colors for Delrin—a new Du Pont thermoplastic. Lag between availability of resin and sale of fabricated articles to ultimate consumer required careful forecast of colors expected to be popular three years in advance. Standard colors shown also had to reflect wide range of expected uses, such as automobile instrument clusters, radio grilles, brush handles, combs, and refrigerator door handles.



High visibility was basis of color selection for the plastic roller skates (rear) designed for children between two and six years of age. The skates must compete in the toy market where impulse buying is the rule. A different set of factors influenced color selection for the line of marine hardware (foreground). Red and white were chosen for the outboard market where a premium is placed on beauty and color. The bronze color was chosen to penetrate markets traditionally held by metals.

proved superior to other colors in any number of tests, including retail sales checks. Yet red is used more predominantly than any other hue. Would the designer pick something else just to be different? Despite its conventionality, red strikes fundamental chords in human beings, and though it may be seen a thousand times, its universal appeal constantly bobs up.

Madison Square Garden reports that a brilliant red-orange cover will sell more programs and box scores than any other hue. Brightness, colors of high visibility—red, orange—will startle the eye. Where attention value is the first consideration, the designer will do far better to study the technical aspects of vision than to sound out the notions of customers. Here it is hard to beat a good vermilion red, a clear sulfur yellow, pure green on the bluish side, and clear blue on the greenish side. Orange may also be acceptable for strong impulse, although it isn't too well liked as a color.

be wary of color choices in utility products

It is commonly supposed that the buying public is happy when it is offered a choice of colors. This is obviously true in fashion products, paints, wallpaper, textiles. But it isn't necessarily true for all things.

If the emphasis on the product is one of functional utility, color choice may be irrelevant and objectionable. A maker of 35-mm projectors once offered his product in a pleasing shade of metallic blue with different colors for the lamp housing. A retail sales check in New York camera outlets showed that the idea was a "dud." All too clearly, the buyer wanted a *good* projector, and if the color was acceptable enough, this was sufficient for him. The color choice, in fact, seemed like a dodge and made the public suspicious.

Colored panels for refrigerators, an offering of

recent times, have likewise failed to amount to much. A refrigerator is a utility item, and it must apparently be accepted or rejected as it stands on the showroom floor—with no digressions.

Telechron once made an electric clock having a plate-glass surrounding panel which could be used to display photographs. In demonstrating this novel and rather logical feature, it displayed the clock in dealers' showcases. Incredibly, people actually looked at the clocks and remarked, "Why would anyone want a clock with the picture of those people on it!"

In some products, the public doesn't want a color choice. It wants to see the finished product and to buy it exactly as it is.

realize that people are often objective with color

What a man may like personally is not always a measure of what decisions he may reach in the purchase of many products. Thus, it is one thing to find out what a man likes and another thing to try to determine what he will do if he thinks things over and is objective rather than subjective in his attitude.

In business typewriters, 90 per cent of demand will be for gray. In portable typewriters, gray will account for only 40 per cent of sales. The objective attitude usually leads to conservatism. Businessmen and architects very often "play safe" rather than attempt to impose their personal feelings on what they specify for others to use. Yet they may by no means be unduly reactionary.

Again, in the business field, while olive green once was practically the only color available in filing cabinets, accounting for 95 per cent of demand, a complete revolution in office-furniture design has relegated it to limbo. One large manufacturer reports today that fully 90 per cent of filing cabinets are gray, with only 10 per cent given to other colors, including olive green.

Thus, in the styling of more durable goods, machinery, and the like, it is generally best to avoid too much impulsiveness in color styling. A shift may be made from darkness to lightness, but the over-all effect may have to be refined. Otherwise, the user may let his brain block his emotions and reject what is offered him, even though he may like it personally.

don't make color compete with function

Foreign sports cars are usually offered in few color choices—black, white, silver gray, red. Why? The purchaser is concerned primarily with good engineering and performance—and finical style details are superfluous. The car must be attractive, yes, but good appearance is incidental.

This attitude seems to go also for such things as machinery, office equipment, cameras, and luggage. In cameras, tradition has approved such conservative shades as black, brown, taupe, gray, all of which are acceptable. What to do, therefore, with a camera?

Here, it undoubtedly would be wise to think less in terms of color *per se* than of general trends in color tone. America today is in a pastel era. Therefore, instead of green cameras or pink ones, how about *lighter tints* of the above-mentioned brown, taupe, and gray? If such were done, the products would look more contemporary, and yet conservatism would still prevail. This shift from dark to light color—an encompassing one—has marked style progress in office equipment, luggage, outboard motors and numerous other products. Practically everything today is wanted in light tone—automobiles, roofing, carpeting. Functional items that reflect the same preference are likely to be successful—even though the shift be merely from battleship gray to pearl gray!

pick colors for logical sales reasons

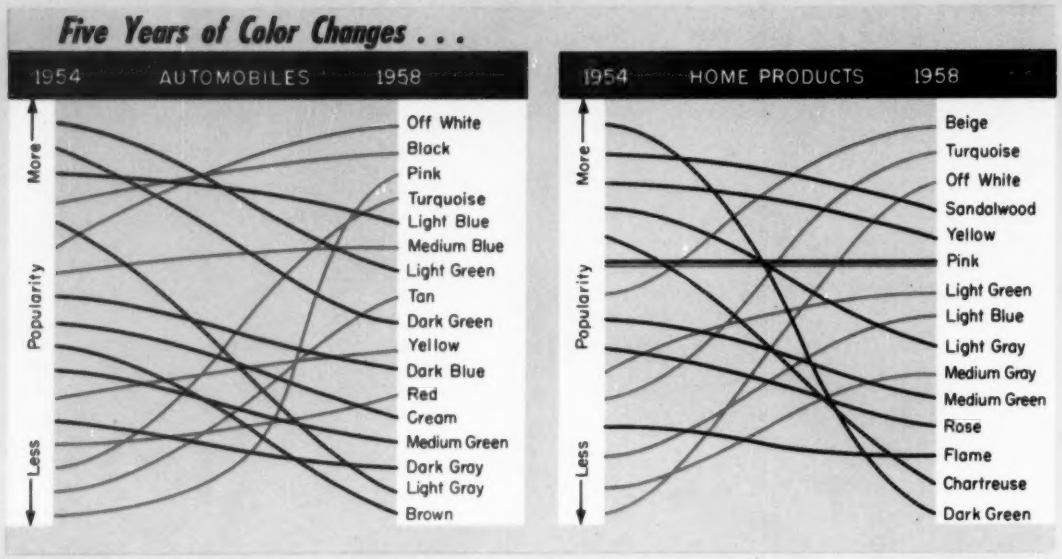
An engineering approach to color often provides an answer to color styling that is virtually unshakable. Consider the appearance design of the Royal office typewriter. Such products are usually bought by office managers and executives who would, if possible, like to avoid imposing their own personal whims. If they are convinced that certain colors are right, they will not only buy them but thank you at the same time.

Here is where product design is on firm ground. Can the color choice be proved functionally? If it can, temperamental arguments by buyers may well fall by the wayside.

In the Royal machine, although color choices are allowed (pearl gray, sandstone, willow green, sea blue, cameo pink), all of them have been established in lightness to agree with good scientific practice.

Many researchers claim the human eye is "strained" where it is constantly subjected to sharp differences in light and dark. The keys of the Royal typewriter are pale in tone and, when seen in relation to white paper in the machine carriage, do not demand trying optical adjustments. By stressing such technical facts as these, and by designing a range of colors which will have the same merit of uniform lightness, Royal is able to supplement styling with intelligent adherence to what ophthalmologists and seeing specialists prescribe as necessary in the efficient performance of visual tasks.

A somewhat similar approach has been used by American Seating for school furniture. Since no one color or color scheme could possibly satisfy all tastes, the color problem was objectively approached. According to psychological study known to school people, blue and red are favorites in all preference ratings. With blue for the framework of its desk, a red coral for the book box, and a yellow woodtone for the top, American Seating could boast: 1. It had the colors most children—and adults—liked best. 2. The combination was both warm and cool.



Color changes in automobiles over the last five years. To a large extent, automobile colors fit in with general color trends, for the same people are involved. In five years, many radical changes in preferred colors have occurred. In particular, off-white was at the top in '58 and, for the first time, pink was among the top sellers.

Color changes in home products over the last five years. Colors preferred most are at the top and those least at the bottom. In this five-year period there has been a general shift from strong colors to pale ones. In individual hues, dark green and chartreuse have more or less disappeared, while beige and off-white have taken over.

3. It blended the traditional primaries of art education. 4. It would, in consequence, be harmonious in any type of schoolroom decor, any region, or room orientation.

give people credit for good color taste

In going through a department store, a person may be struck by the fact that the American public buys a lot of junk. But this is not a fair indictment of public taste at large; people are surprisingly sensible. Salt and pepper shakers resembling a Dutch boy and girl, and held on the shelf of a windmill, will be countered by other salt and pepper shakers which are simply and beautifully styled—and perhaps sell far better.

If there is a tendency toward the baroque in more or less decorative items and home accessories, let the product designer not be unduly confused and reach false conclusions that everything made must be adorned with furbelows.

A short while ago Taylor Instrument checked consumer wants in an outdoor thermometer. In the first opinion poll, a new Taylor design failed to have the appeal of a competitive product: The competitive design scored 58 per cent; the Taylor design, 42 per cent.

Changes were made. The public quite definitely said it preferred a combination of black and white on a round dial, with all numerals the same size. The customer said this design was easiest to read. Though conventional, it constituted good styling because it had dignity and functional reason. With the Taylor product improved, a similar poll put it on top—for Taylor, 71 per cent; for competition, 29 per cent.

Such everyday products as thermometers, kitchen and alarm clocks, wall thermostats can be harmed with too much "fanciness." They can be neat, attractive, well proportioned, well colored, but all elements should add up to true utility. Sure appeals are to be found in such "universal" colors as white, black, gray, red, cool green, with more exotic hues likely to have ephemeral life.

co-ordinate product color with environment

Few products stand by themselves in the judgment of the public. Where will they be used, and what about their environment?

All companies would like, if possible, to hold styling above and in advance of competition. The Hoover vacuum cleaner, for instance, is obviously for home use and for carpets and flooring materials in homes. During recent years Hoover has done an outstanding job of styling by carefully observ-

A warm tone of Garland green was selected for the 1959 Hoover cleaner since more homes have green interiors than any other color. And this shade of green is the one currently in the best of fashion—a fact proved by actual studies of carpeting sales.

ing the various goings on in the homes of the nation.

At a time when general trends in home furnishings shifted to beige it developed a stretchable hose of plastic for its canister model. This hose, formerly made of woven cotton and which had to be dark to conceal soiling, could be lightened in tone—and this was done. A year later, the beige was brightened to a pearl white, again to meet national trends. The light hose, and the generally bright appearance of Hoover cleaners, made them outstanding in competitive markets.

As to the body of the cleaner, color tones were shifted from taupe, to rose, to gold in succeeding years. The 1959 upright and canister cleaners are both garland green. Why?

Hoover research has been devoted to trends in carpet colors. First of all, fully 75 per cent of homes have green rooms. Green in carpet has undergone constant change, from dark, to cool light tints—all a matter of actual record. With the assistance of a leading carpet manufacturer, Barwick Mills, the ever-popular appeal of green was deliberately researched and sales-tested. At a time when the shift in higher-priced carpet moved to a warm shade (1958), Hoover chose this color as a fashionable one for 1959. In current markets, and for similar equipment, very sure colors would be off-white, beige, turquoise, warm gray, red and, to some extent, pink.

don't ask people which colors they like

In the research experience of the writer, consumer polls on color have been more or less abandoned for many years. They just haven't worked out because human emotions are unreliable and inconsistent. Although a woman may offer practical and reliable judgment on shape, purpose, and operating function in a product, she may express purely temperamental reaction to its hue. This has been learned through bitter trial by many organizations.

When Schick introduced four colors in its electric shaver, 250 of them were once offered as free gifts to a group of businessmen. Their preferences were red (42 per cent), beige (24 per cent), green (23 per cent), white (11 per cent). Yet when the shaver itself went to market, the actual sales of several thousand units were white (36 per cent), beige (25 per cent), green (21 per cent), red (18 per cent).

Where red had been top choice when the situation offered the purely emotional pleasure of getting something for nothing, it was at the bottom when the buyer had to think things over and pay out of his own pocket.

To quote another experience: In 1954 when colored home appliances were about to be put on the market, a careful study of general color trends revealed great potentiality for pink. First off, management itself recoiled—who would want a *pink* refrigerator? A quick consumer poll (several hundred office employees and housekeepers) revealed almost complete neglect of pink. Mention of it was insignificant.

Yet in the experience of one manufacturer, when pink finally went to market it accounted for over 40 per cent of his color sales in one year—and made his competition jump after him!

Consumers are poor judges of color simply because they do not know today what they will want tomorrow. It is largely a waste of time to ask them. In the normal course of trends, colors move up from low positions to high ones—slowly but surely. There is a rising stream of public consciousness not yet known by the masses at large, or even sensed. However, the consumer will feel the push of this current in due time. This is precisely what happened in the case of pink. It was a mere dribble at the time the public was asked about it. Naturally the reaction was negative.

A color of similar potential today—like pink was a few years ago—would be beige; yet it is not commonly seen in appliances. Beige constitutes a dominant and basic shift in consumer wants, and as such it could be confidently applied to numerous products used inside and outside the home.

consider a different color line for each market

All too often, the choice of color in consumer goods is looked upon as a straight-line procedure, which it seldom is. The product designer may elect to analyze a harmonious and related range of hues,

Primary colors—red, yellow, blue—enhance American Seating's school furniture. The appeal of the design is simple, direct and highly appropriate to school use, but styled in special and attractive shades.

choosing the right color

thinking erroneously that he is dealing with an orderly series of co-ordinated colors. This is rarely the case and, if it is pursued, the color choice may well miss a fat part of the market.

With a product like the Royal portable typewriter, preliminary study was devoted to types and classes of buyers, each of which might have different ideas about color appearance. A portable typewriter might be wanted by lawyers, newspaper men, writers, whose tastes would naturally be conservative. The machine would be bought almost wholly for its utility, and any flashy styling would be rejected. Good colors here would be gray, beige, green.

A housewife might want the machine to fit in with the decor of her home. Here would be another attitude toward color, and off-white, blue, green, rose would be in the stream of home fashion trends. Still again, thousands of portables are purchased—usually as gifts—for college and high-school students where the styling must have a lively and striking quality—red, turquoise, yellow.

The same strategy may be necessary in many other products. The automobile industry, for example, is well aware of the conservative-modern contrast in styling, and the convertible and sedan will have markedly different appeals. Fortunately, the modern, or more dynamic, effect may often be used as a promotional come-on. One manufacturer of gas ranges uses a bright red product for display purposes. This arrests the attention of the public, has strong impulse appeal, even though the buyer may end up purchasing a conventional white model. There is wish fulfillment in the brilliant color. It may constitute the "dream" that motivates action in other channels. The point is that color styling cannot be all dreams or all conservatism, but in reality a combination of both in different appearance designs for the same product.

be flexible if colors must be standardized

Color standardization is the delight of all production men. Why can't the problem of color be stripped of its temperamental aspects and brought into line with sound and efficient manufacturing?

There is a very straight answer—color wants change for the simple reason that people are not likely to buy the same thing twice. Yet standardization is not beyond the realm of practicability if it too is willing to submit to change. The trouble is that standardization too often is looked upon as a fixed tableau rather than a moving-stage production.

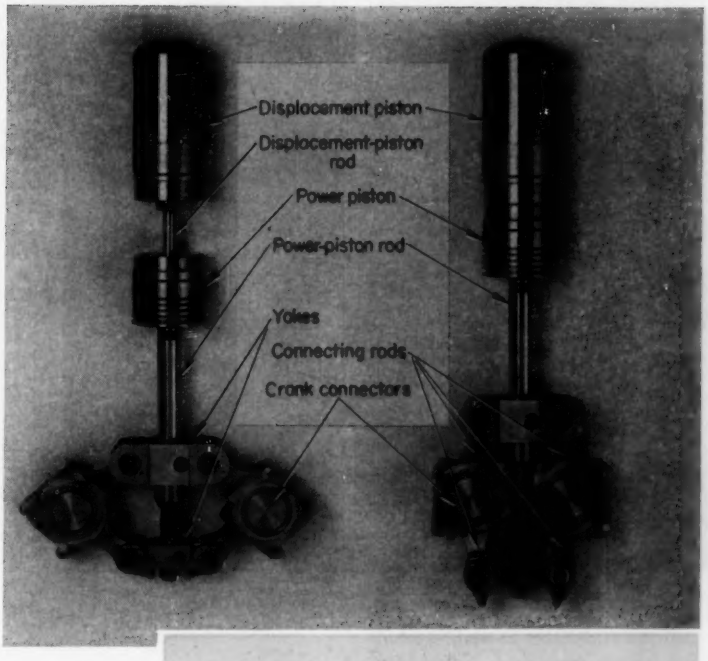
Many standardization efforts have failed because they have been frozen hard and then abandoned. Obsolete today are standards once set up for sanitary ware, bathroom fixtures, kitchen accessories, school furniture, polystyrene and urea plastics, and several other things.

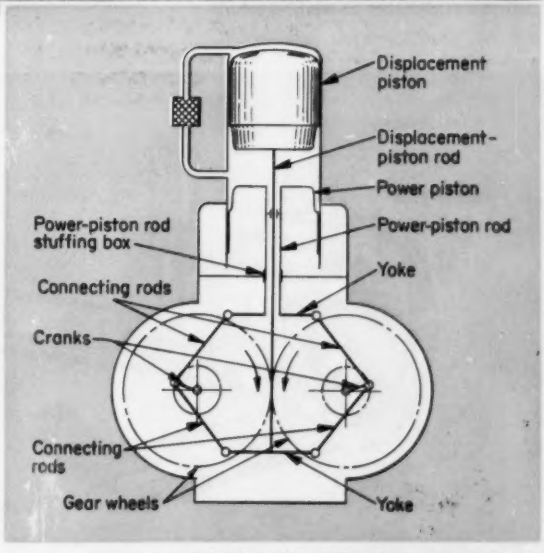
Yet color standards will work if they are raised as children and not left as foundlings on a doorstep. A good example are the standards recently set up for Delrin, a new Du Pont plastic. While Du Pont could have started out by matching any colors submitted by its customers, this would be a rather costly procedure; color formulations might promptly run off in all directions at once. Yet arbitrary standards would also be limiting and by no means acceptable to the plastic user.

Thus, for a period of several months, research has been devoted to color acceptance in such products as appliances, automobile trim, business machines, hardware, kitchenware, and a miscellaneous list of pens, combs, eyeglass frames, toys, etc. Color acceptance has been carefully checked and then double-checked against general color trends to anticipate possible shifts in human desire for the immediate future.

The result: 14 basic standards which will be put into mass production, and 46 reserve or service colors which will be preformulated and offered on request. This is no theoretical or haphazard list. Du Pont can quote the results of its research, show initiative in the matter of color acceptance and thereby make a good product good looking—with colors which it has justifiable reason to know will satisfy the public.

scanning the field for *ideas*

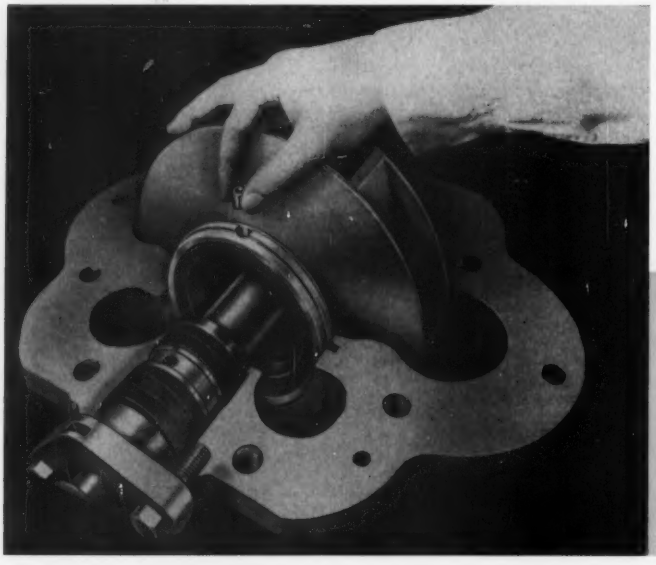


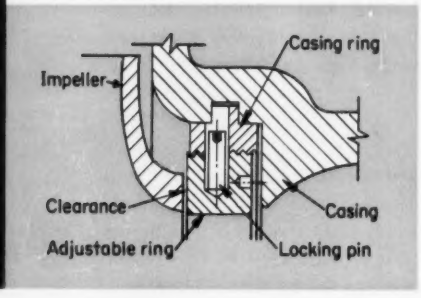


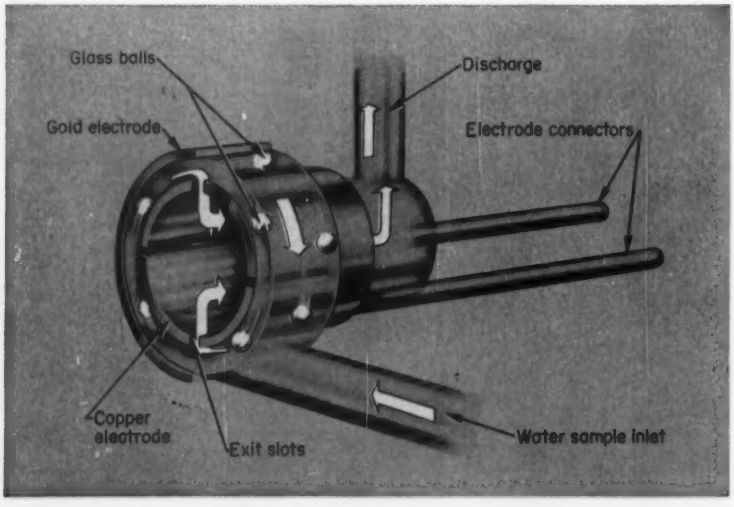
Photos, courtesy Philips Research Laboratories

Rhombic drive linkage co-ordinates coaxial piston movements and simplifies dynamic balancing of inertial forces of moving parts. Driving mechanism consists of twin crank and connecting rod assemblies offset from the piston centerline. The cranks rotate in opposite directions and are coupled by two gearwheels. The power piston is attached to a yoke by a hollow piston rod, and each end of the yoke is connected to one of the twin cranks by a connecting rod. The displacement piston is connected to a yoke by a piston rod which passes through the hollow power-piston rod. This second yoke is also linked to the twin cranks by connecting rods. Since all connecting rods are of equal length, the rods form a rhombus in which only the angles vary when the system is in motion. The mechanical efficiency of this arrangement is high since the horizontal force components exerted by each pair of connecting rods are exactly balanced at each yoke and the power-piston-rod stuffing box is subject to no lateral thrust. Reported by R. J. Meijer in *Philips Technical Review*, the drive mechanism is used in a hot-gas engine developed by Philips Research Laboratories, N. V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands.

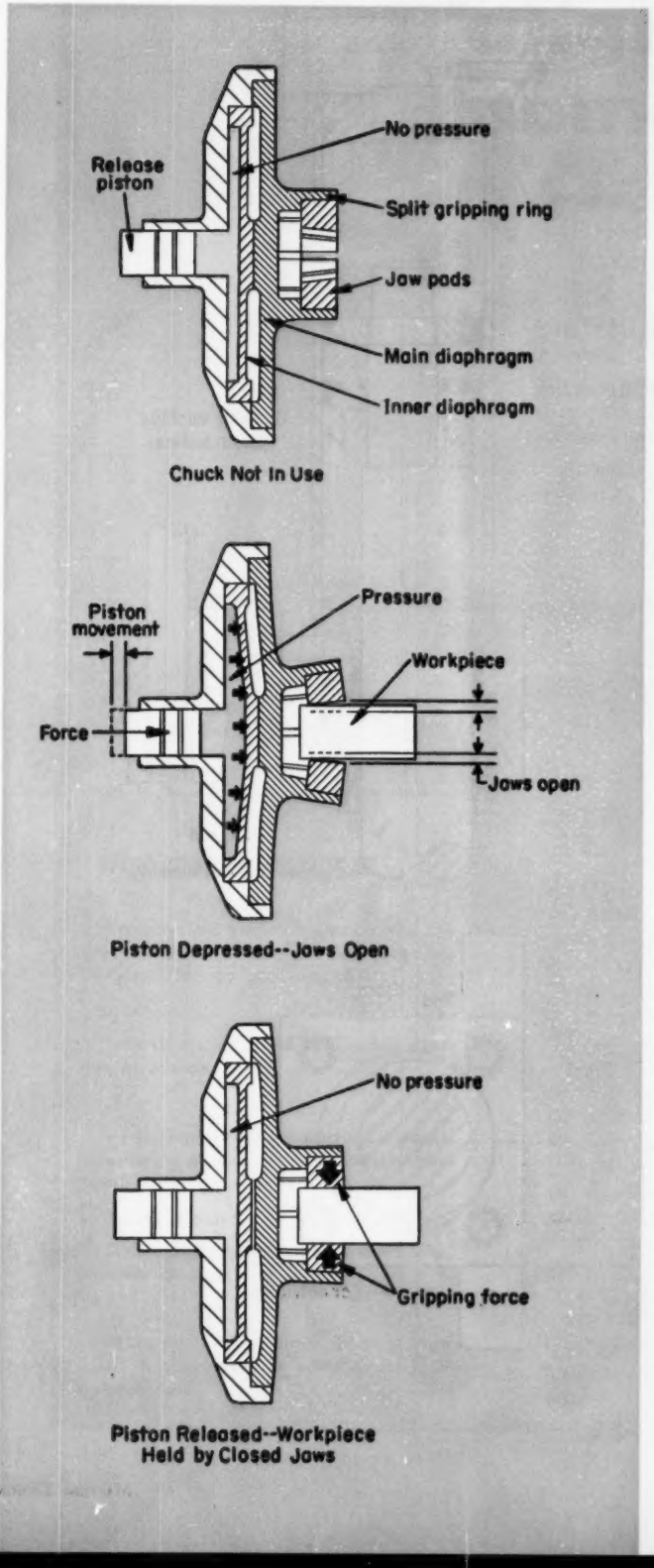
Adjustable wear ring permits a self-cleaning clearance to be maintained between mating rotating and stationary surfaces without disassembly of rotating parts. The adjustable ring set consists of one righthand and one lefthand thread assembly. The outer ring of the set is mounted in an annular groove in the casing. Rotation of the outer ring drives the inner ring, which contains the wearing surface, in an axial direction. After the proper clearance is set, a pinhole is drilled in the adjustable ring and a pin is inserted to prevent movement between the two rings. The correct clearance setting in the ring produces pressure and velocity differentials necessary to eliminate seizing or freezing of rotating elements. Wear ring principle employed in double suction pumps developed by Allis-Chalmers Mfg. Co., Milwaukee, Wis.







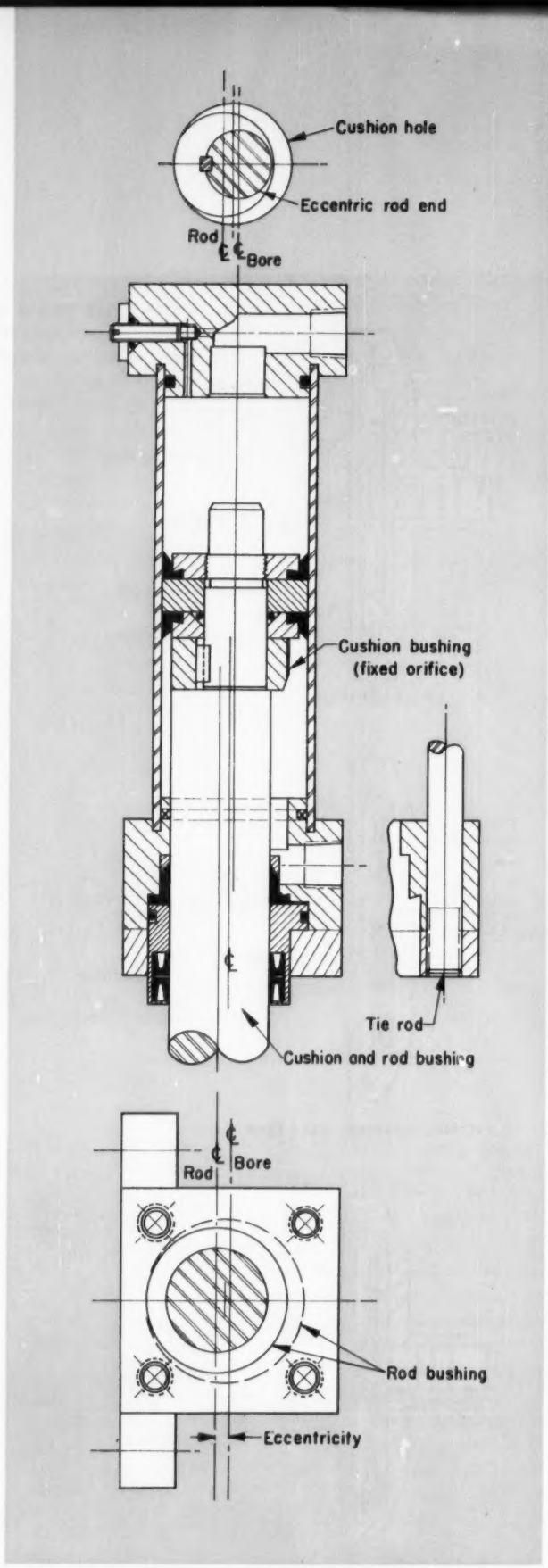
Circulating glass balls clean dissimilar metal electrodes to prevent deposit buildup produced by electrolytic action in a "fluid" current-generator. The glass balls are retained between two-ring shaped electrodes which generate a current as the electrolytic fluid passes between them. As the fluid circulates, the balls, carried by the fluid continually wipe the electrode surfaces free of deposits. Cleaning principle employed in Depolox residual analyzer manufactured by Fischer and Porter Co., Hatboro, Pa.



Dual steel diaphragms develop high gripping forces in a clamping system actuated by a self-contained hydraulic pressure unit. A main diaphragm carries a split gripping ring on its external face while an inner diaphragm, with a projecting central boss, forms one wall of an internal chamber filled with hydraulic fluid. The chamber is connected to a small cylinder containing an externally actuated piston. As the piston is depressed, the fluid pressure increases, causing the inner diaphragm to deflect outwards. The boss acts on the main diaphragm and causes it to distort, producing a small outward radial movement of the split gripping-ring segments.

Elasticity of the material returns the diaphragms to their unstrained position when the piston is released. This action forces the jaw pads, attached to the ring, to grip an object placed between them. In the gripping position, the diaphragms are under no pressure from the chamber. Hence, gripping action is independent of externally applied forces and depends only on the elasticity of the main diaphragm and the amount by which the gripping ring is held open by the object. As reported by Alan K. Jackson, the diaphragm principle is used in the Everac chuck developed by Integral Ltd., Wolverhampton, England.

Offset piston-rod in fluid cylinders prevents rotation of shaft for push or pull operations. Need for external guide bars or ways to control rotation of the cylinder output rod is eliminated since the rod restraining device is completely contained within the cylinder. Restraint is obtained by mounting the rod in an eccentric bushing so that the rod centerline is parallel to but offset from the cylinder bore centerline. Hence, any tendency toward twisting imparted to the piston is resisted by the rod. The amount of offset is governed by the size of the cylinder bore. Rod design, on which patent is pending, developed by S. Lee Lipsman, senior designer, Photographic Div., Bulova Watch Co., Woodside, N. Y.



Quick and easy ways to make . . .

alignment nomograms

. . . the engineer's own time and labor savers

DIMITRI KECECIOGLU
Assistant to Director of Mechanical Engineering

HAROLD M. WEISSMAN
Office, Director of Mechanical Engineering, Industries Group

Allis-Chalmers Mfg. Co.
Milwaukee, Wis.

why make nomograms?

1. Lengthy and repeated calculations are unnecessary to obtain one or a number of values for the same variable.
2. Values are obtained in a small number of operations.
3. At a glance, readers can tell in which direction, and how much, to change independent variables.
4. Accurate interpolation and extrapolation are possible.
5. Often, more usable data can be packed into less space than by other methods of presentation.

RECURRENT calculations can be dispatched accurately and quickly by the use of graphic aids. Curves plotted in Cartesian co-ordinates do the job well. Alignment nomograms often do the job better.

Many books and articles treat the mathematics of nomography. Alternatively, this article presents techniques, all graphic, with which engineers can readily help themselves.

From original graphs in Cartesian co-ordinates, alignment nomograms can be constructed for a single curve, a pair of curves, or a family of curves. The curves can represent known equations or empirical data.

Inevitably, errors in Cartesian graphs carry over to alignment nomograms. But, recalibrated nomogram scales,[1] carefully plotted, and ease of reading nomograms reduce these errors substantially. If a family of curves is exactly "bilineal," better than 1 per cent agreement can be expected between Cartesian values and alignment readings.

A simple graphic test for "bilineality" is illustrated in Fig. 1. To confirm initial results, the test should be carried out at several different points on

[1]References are listed at end of article.

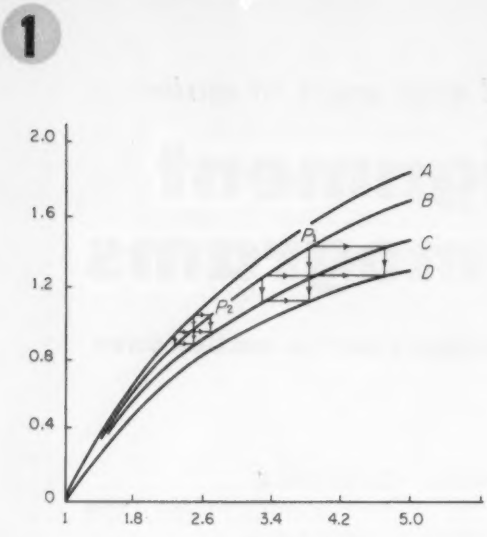


Fig. 1—Test for bilineality. Horizontal and vertical lines drawn from points, such as P_1 and P_2, must close to form rectangles.

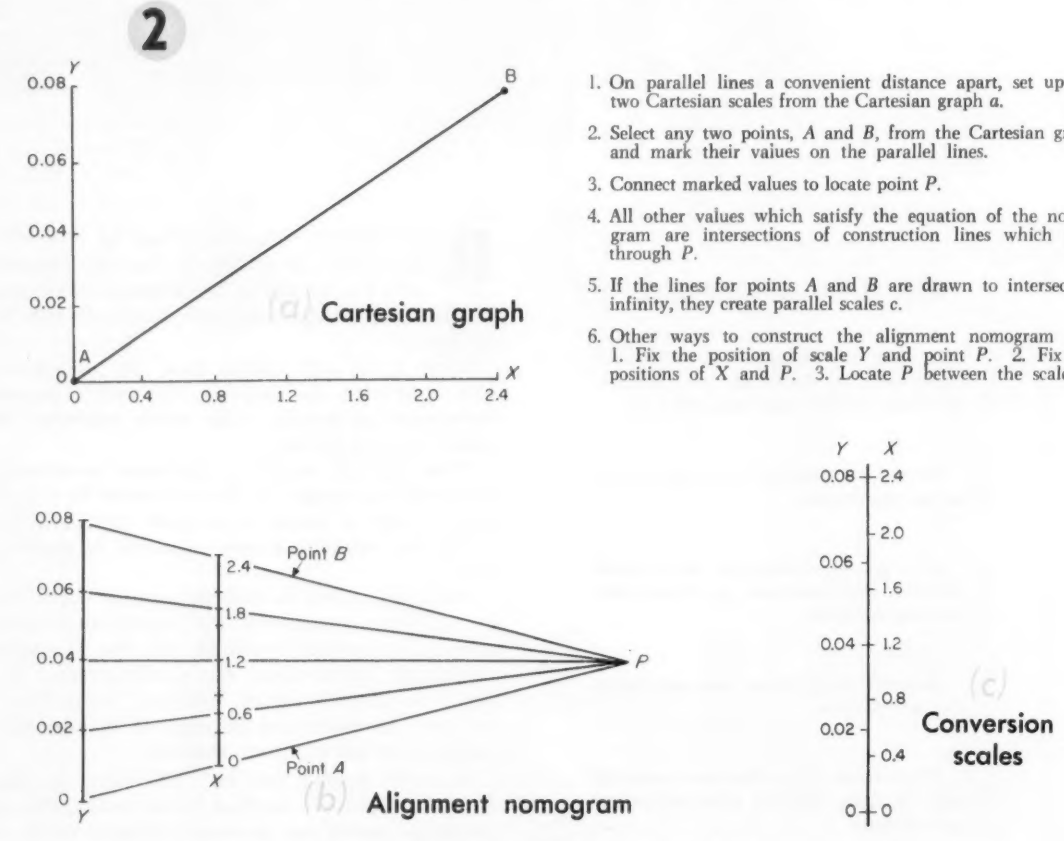
the curves. Although portions of curves are bilineal, it is not necessarily true of entire curves. Furthermore, if several curves of a family are bilineal, it does not follow necessarily that all curves in the family are bilineal.

As the curves in a family diverge from bilineality, their accuracy decreases. The extent of inaccuracy can be found by comparison of values obtained graphically from their Cartesian graph and alignment nomogram. With these results, one or more of the transformed scales in the alignment nomograms can be recalibrated.[1]

Should there be slight deviation from bilineality, points plotted for the third, dependent, scale of a three-scale nomogram will form areas rather than points. The bigger the areas, the less accurate the nomogram. But all is not lost. The centroids of the areas can be used for an alignment nomogram approximating a true function.

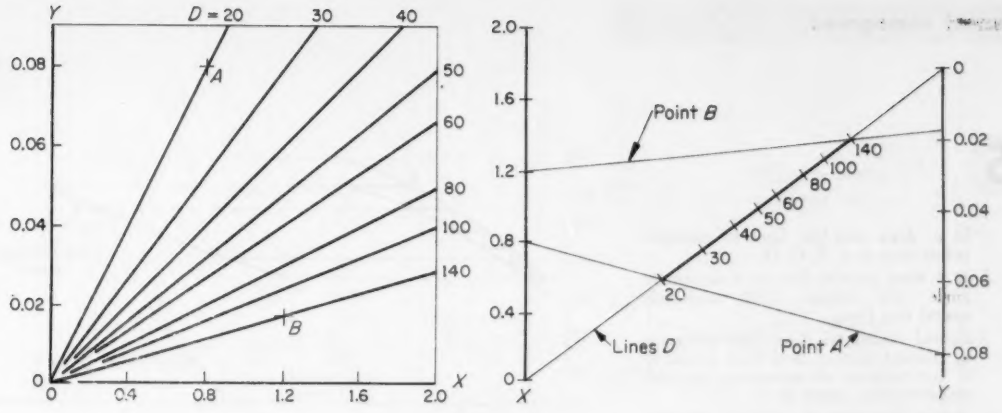
Conversion of Linear Functions: Construction of an alignment nomogram from a straight-line nomogram is shown in Fig. 2.

The relationship between three variables is frequently expressed by a family of curves. Accordingly, a third scale is created in the alignment nomogram, Fig. 3.



1. On parallel lines a convenient distance apart, set up the two Cartesian scales from the Cartesian graph *a*.
2. Select any two points, *A* and *B*, from the Cartesian graph and mark their values on the parallel lines.
3. Connect marked values to locate point *P*.
4. All other values which satisfy the equation of the nomogram are intersections of construction lines which pass through *P*.
5. If the lines for points *A* and *B* are drawn to intersect at infinity, they create parallel scales *c*.
6. Other ways to construct the alignment nomogram are: 1. Fix the position of scale *Y* and point *P*. 2. Fix the positions of *X* and *P*. 3. Locate *P* between the scales.

Fig. 2—Cartesian graph converted to an alignment nomogram and conversion scales.



(a) Cartesian graph

(b) Alignment nomogram

3 **Fig. 3—Conversion of a family of curves in Cartesian co-ordinates to an alignment nomogram.**

1. Select points, such as *A* and *B*, on each curve.
2. Draw and calibrate parallel lines for values of *A* and *B*, as in Fig. 2.
3. Establish a scale for *D* by connecting the zero points of both scales, since all lines *D* pass through the origin in *a*.
4. For a number of other points on lines *D*, determine *x* and *y* values from *a*. Connect corresponding values in *b*. Mark intersections on scale *D* in *b* with corresponding values of *D*. Repeat as often as necessary to calibrate scale *D* in the alignment nomogram.

Transformation of Nonlinear Functions: By transformation of scales, alignment nomograms can be graphically constructed from nonlinear functions. The method is illustrated in Fig. 4. In constructing an alignment nomogram, the transformed scale X' and the scale Y are used the same as in Fig. 2.

Simultaneous transformation[2] of two nonlinear functions is illustrated in Fig. 5. The relative lengths of the two transformed scales, Fig. 5*b*, are governed by the angle at which the parallel lines are drawn. The distance between the parallel lines governs the absolute lengths of the transformed scales. An alignment nomogram can be constructed using the transformed scales by the method illustrated in Fig. 2. Curve families must be bilineal to be transformed into straight, parallel lines.

4

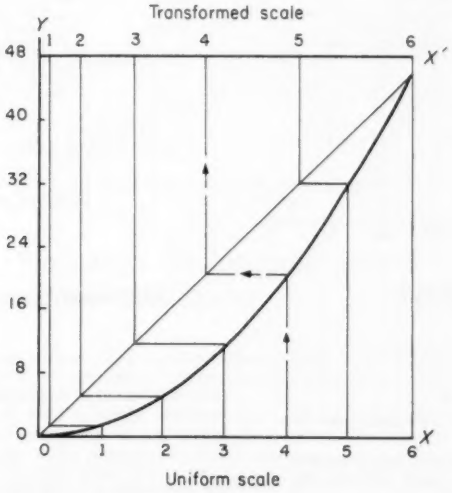


Fig. 4—Construction of a transformed linear scale for a nonlinear function. Projections, starting from the uniform scale, are made as arrows indicate.

Interpolation and Extrapolation: If a family of curves is bilineal, entirely new members of the family can be constructed, either by interpolation or extrapolation, Fig. 6. This is true even if the Cartesian co-ordinates of only one point on the new curve are known. Of course, the accuracy of an extrapolated curve depends heavily on the accuracy of extensions to the family of transformed curves.

Presentation of Complex Equations: Alignment nomograms can simplify the presentation and use of complex equations. Consider the problem of determining the natural frequency of a rectangular beam supported in three different modes. The equation is

$$f = a_1 \left(\frac{EI}{PL^4} \right)^{\frac{1}{2}}$$

where f = natural frequency of beam, a_1 = frequency factor dependent on end conditions, E = modulus of elasticity, I = moment of inertia of beam cross-section about neutral axis, P = weight of beam

5

1. In *a*, draw step-like lines to establish points such as *A, B, C, D*.
2. In *b*, draw parallel lines at a convenient angle and connect with uniformly spaced step lines.
3. Extend horizontal lines from points in *a*. Extend vertical lines from points in *b*. Intersections of extensions establish transformation curve in *c*.
4. Repeat similarly to establish transformation curve in *d*.
5. As arrows indicate, original uniform scales in *a* are converted to transformed scales *X′* and *Y′* by extensions through the transformation lines.

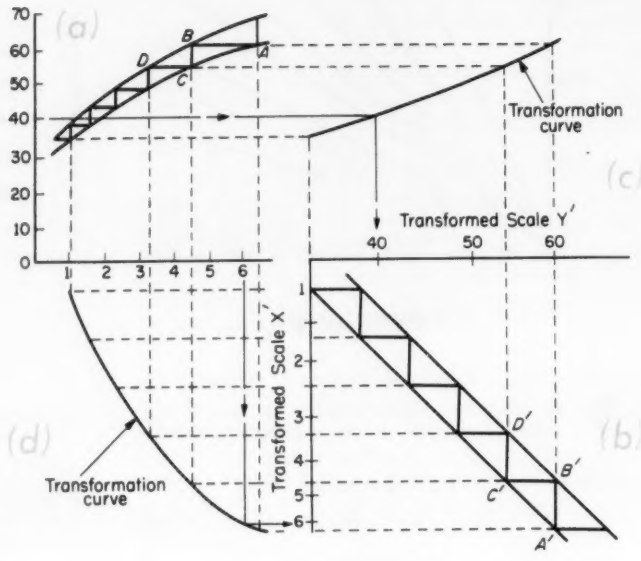
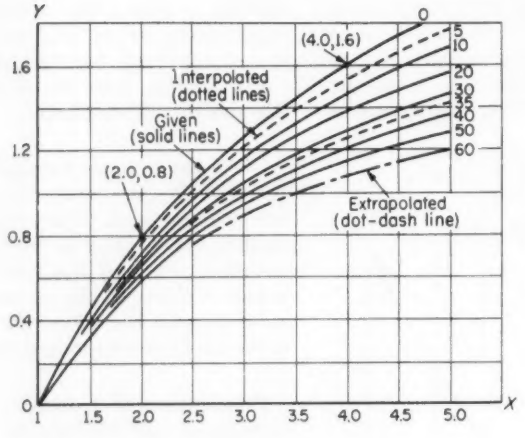


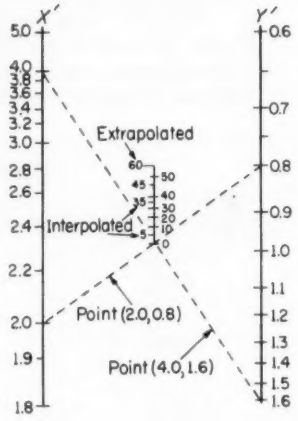
Fig. 5—Simultaneous transformation of two curves to straight lines.

6

Fig. 6 — Interpolation and extrapolation in a family of curves.



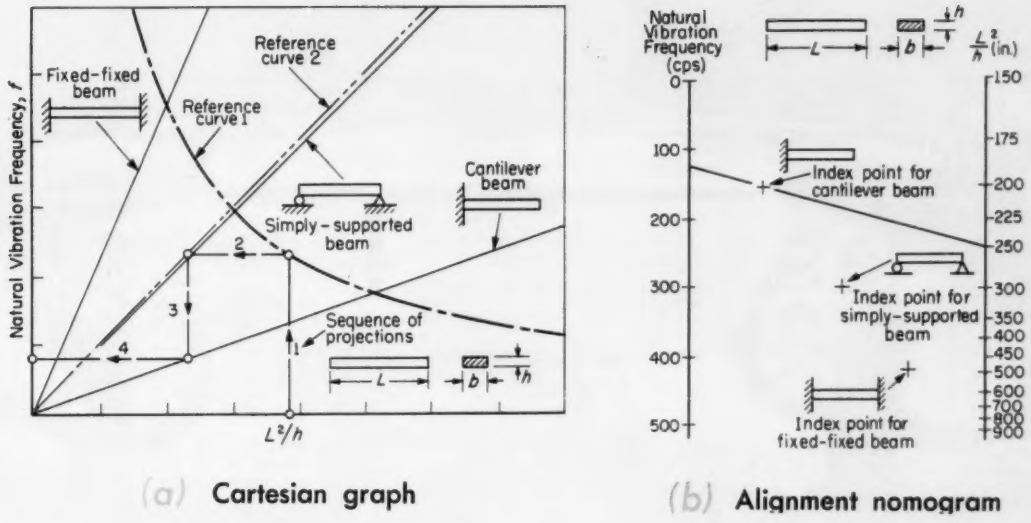
(a) Cartesian graph



(b) Alignment nomogram

The general procedure is:

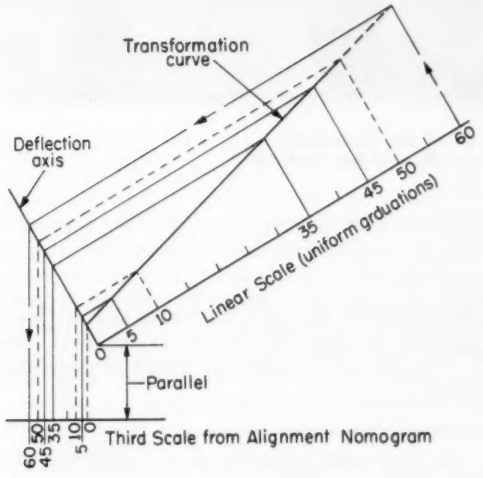
1. Test the family for bilineality, as in Fig. 1.
2. If the curves are bilineal, construct the transformation curves and calibrate the new scales, as in Fig. 5.
3. Use these transformed scales to construct the alignment nomogram, *b*.
4. Calibrate the third scale in the alignment nomogram with graduations which represent "given" curves in *a*.
5. Interpolate or extrapolate on the third scale by means of a transformation curve and a linear scale, *c*, and transfer the interpolated or extrapolated points to the alignment nomogram. The same points may be used to plot the interpolated or extrapolated curves on the original graph, *a*.



(a) Cartesian graph

(b) Alignment nomogram

Fig. 7—Conversion of a complex equation[4] from Cartesian co-ordinates to an alignment nomogram.



(c) Projections for interpolated and extrapolated curves

1. Lay out a linear scale (uniform graduations) perpendicular to the third alignment nomogram scale, same size or expanded.
2. Project lines from the linear scale and from the third scale.
3. Connect intersections to form transformation curve.
4. Mark desired interpolations, such as 35 and 45, project back to third scale.
5. For extrapolations, extend transformation curve, in accordance with its trend, as from 50 to 60. Project extrapolated point, such as 60, back to third scale.

material per unit length, and L = beam length.

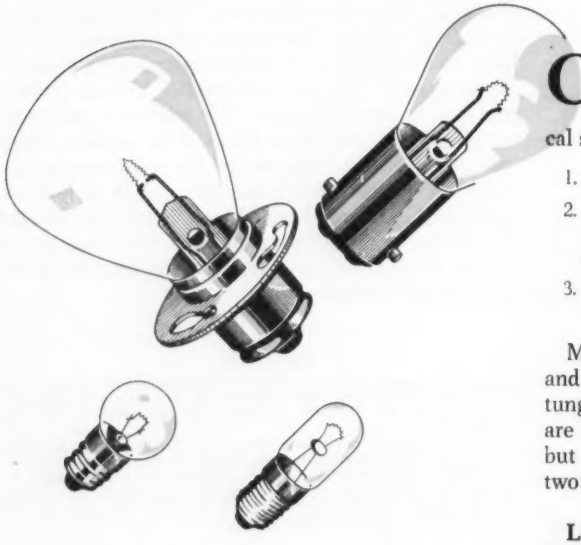
For beams of steel or aluminum, Fig. 7*a* is the Cartesian graph of the frequency equation. To find f, four lines must be drawn. The alignment nomogram, Fig. 7*b*, requires only one line.

To obtain the nomogram, the L^2/h scale is transformed so that reference curve 1, Fig. 7*a*, becomes a straight line. The transformed but inverted L^2/h scale and a linear L^2/h scale, corresponding to reference curve 2, are laid out parallel to each other a convenient distance apart. The reference point corresponding to reference curve 1 is located. From the transformed L^2/h scale and the point corresponding to reference curve 1, the linear L^2/h scale is recalibrated. This recalibrated scale is laid out parallel to the linear frequency scale, and the three points which account for the three different types of beam supports are located.

REFERENCES

1. A. Wertheimer—"The Graphical Transformation of Curves into Straight Lines and the Construction of Alignment Charts," *Journal of the Franklin Institute*, Vol. 219, March, 1935, pp. 343-363.
2. A. L. Levens—"The Transformation of Families of Data Curves to Alignment Nomograms with Applications to Stress Data," *Society of Experimental Stress Analysis, Paper* 452, 1957.
3. R. A. Di Taranto—"Charts Simplify Calculation of Natural Frequencies in Beams," MACHINE DESIGN, Vol. 29, No. 10, October 3, 1957, pp. 133-137.

Many types of miniature lamps are used to internally illuminate all of the instruments in this DC-8 cockpit. Integral instrument lighting, with pointers and scale markings glowing in red light, is standard design for this new jet passenger plane.



CHOOSING the right lamp may at first glance seem literally like a stab in the dark. But the process is easy if performed in three logical steps:

1. Determine the lighting requirements.
2. Note other factors dictated by the application, such as space limitations, electric power supply, expected lamp life, and other environmental influences.
3. Match foregoing requirements with available lamp bulb shapes, base designs, filament types, etc.

Miniature lamps are of two types: Incandescent and glow. Incandescent lamps depend upon a heated-tungsten filament for producing light. Glow lamps are electric-discharge lamps. They have no filament but produce light by the passage of current between two electrodes through a gas such as neon or argon.

Light Requirements: Where the light source is to be viewed directly, as with indicator lights, candle-

For illumination or indication, miniature light sources are available for almost any application. They exist in a profusion of types and ratings. But, which one is best for the job? Here's a guide to . . .

Selecting Miniature Lamps

J. D. LASH and J. W. TUTTLE
Illuminating Engineers
Miniature Lamp Dept.
General Electric Co.
Cleveland, Ohio

power required may range from 0.01 to 10 cp depending upon surrounding brightness. Where an object or surface is to be illuminated, more light may be required if the object has low reflectance. Size of the surface or object is also a factor. A bedroom clock requires little light. An advertising clock requires much light. Where light must be projected, either a separate or a built-in reflector (sealed-beam) may be required. In this case, beam candlepower and beam spread should also be considered.

Spectral quality or color of light can be modified by translucent or transparent coatings applied to the bulb. Outside the visible range, small but useful amounts of ultraviolet and appreciable amounts of near infrared are emitted.

Color distinction may also be obtained with blue argon and orange neon lamps. Although argon lamps are useful for some photographic and fluorescent applications because they produce limited quantities of near ultraviolet light, their light output is only about one-third that of neon lamps.

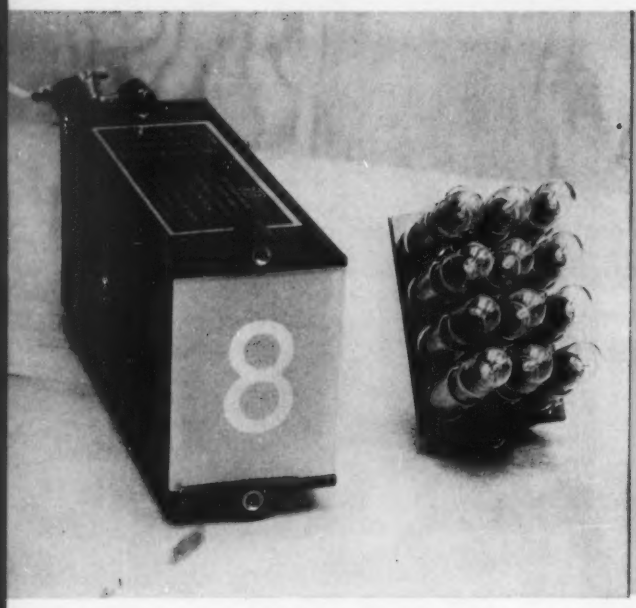
Space Requirements: As lamp size is reduced, particularly below popular radio-panel lamp sizes, prices go up, while quality and performance are likely to go down. Where very small size is the important criterion, as for surgical lamps, other factors must be compromised. Space required for sockets of screw-base lamps is less than for bayonet-base types.

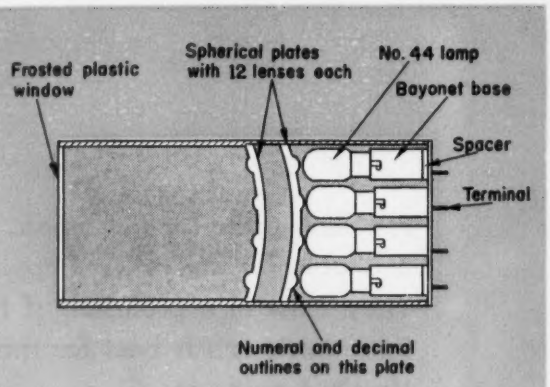
Tolerances of bulb diameters, light-center length, and over-all length should be carefully considered when specifying lamp housings and other related equipment. Since these tolerances are subject to change, the latest information should be obtained if design space is cramped.

Voltage and Power Source: The majority of glow lamps operate in series with a current-limiting resistor in 120-v circuits. However, glow lamps may also be designed for 220-v circuit operation. Minimum voltage at which most glow lamps will operate is 65 v ac or 90 v dc.

Miniature incandescent lamps are normally designed for operation from batteries or generators supplying less than 50 v. Operation in higher-voltage circuits is possible with the use of suitable transformers or resistors.

Mean effective voltage delivered by dry-cell bat-





One dozen No. 44 lamps provide built-in illumination in this numerical output indicator. Clear, easy-to-read numbers with either a right or left-hand decimal are projected on a frosted plastic window by energizing the proper lamp combination. Made by Industrial Electronic Engineers, North Hollywood, Calif., the design eliminates any need for moving parts. Each lamp is designed for a 3000-hr expected life at 6.3 v.

Selecting Miniature Lamps

teries is generally higher than average volts and should be the design voltage of the lamp. Design voltages for flashlight lamps have been determined by extensive tests. Where space permits, larger rather than smaller dry cells should be chosen to reduce power cost. When transformers or resistors are used, delivered volts must be precisely known to obtain proper light and life. Proper operation of some lamps having metal bases also requires that the base shell be negative in a dc circuit.

Vibration and Shock Resistance: High - voltage, low-current incandescent lamps do not withstand any appreciable amount of shock or vibration. By contrast, low-voltage, high-current lamps are quite rugged because of their short filaments. Glow lamps, having electrodes but no filaments, will withstand great amounts of shock and vibration.

Other strength factors for incandescent types are resonant frequency of lead wires, support wires, and filament coil, as well as filament form and number of anchors. Most radio-panel lamps, rated at 6.3 v and lower, incorporate mounts whose resonant frequency has been synchronized with that of the coiled filament to withstand shock and vibration.

Under vibration, screw-base lamps tend to work loose. For severe service conditions, bayonet-base lamps, which lock into their sockets, should be used.

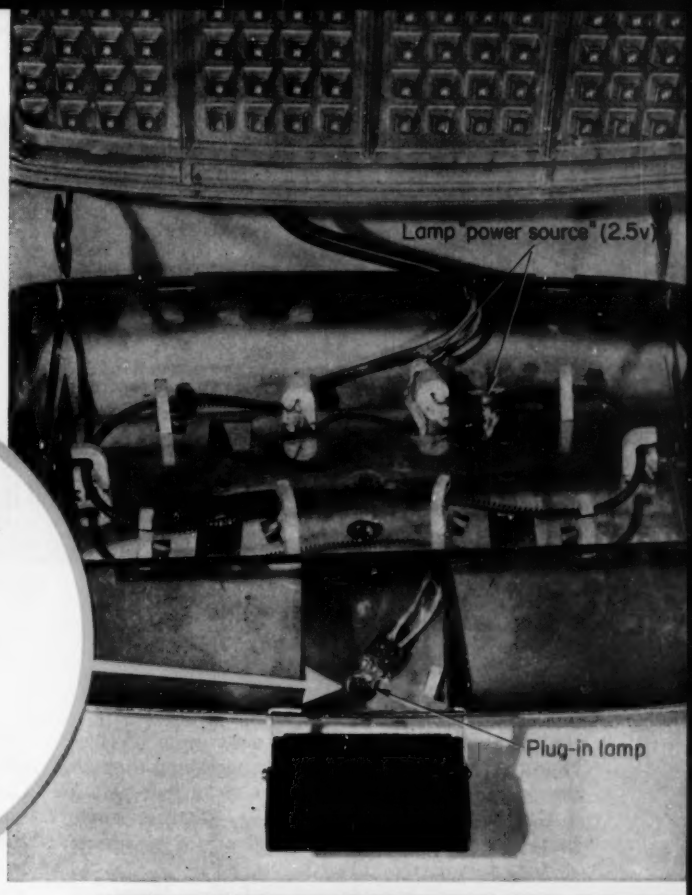
Lamp Life: A miniature incandescent lamp should produce light economically and efficiently during its life. However, life and efficiency are inter-related in such a manner that to obtain one, the other must be sacrificed.

Lamps designed for 6 to 12 v are usually the most efficient, i.e., they produce the most light per watt consumed. As rated voltage decreases from 6 v, lead-in wires conduct heat from the filament at an increasingly greater rate with correspondingly reduced efficiency. For example, a 5.0-v flashlight lamp has an efficiency of 1.0 candle per watt; a 3.7-v flashlight lamp has an efficiency of 0.87 candle per watt; a 2.5-v lamp has an efficiency of 0.67 candle per watt; and a 1.25-v lamp has an efficiency of 0.25 candle per watt.

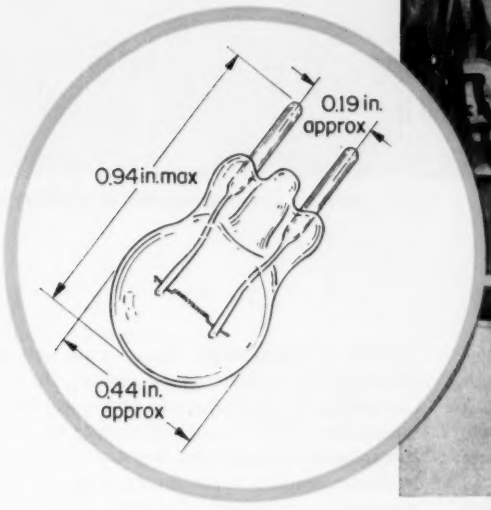
Tungsten-filament lamps, which operate at temperatures of 4000 to 5000 F, are very sensitive to applied voltages. If above-normal amounts of light are desired, a lamp may be operated at voltages above rating but with a sacrifice in life. Light output of a filament lamp varies directly as the 3.6 power of the applied voltage, but life normally varies inversely as the 12th power. For example, a 6-v lamp operated at 5 v gives one-half its normal candlepower and 10 times its normal life.

When a series resistor is used with a filament lamp, lamp life will be approximately one-half that obtained with a transformer. As the filament evaporates, its resistance increases and series current drops. Consequently, resistor voltage drops and lamp voltage must rise proportionately. In addition, size, heat, and cost make series resistors less desirable. With transformers, voltage remains constant.

Selecting lamps for battery operation is a special problem of balancing lamp voltage, life, and candlepower against battery life and current drain. Power cost of operating lamps with dry cells is relatively high compared to cost of using standard household current. For example, Size D batteries (flashlight cells) produce power at approximately $50.00 per kw-hr. The larger 6-v lantern battery operates at approximately $25.00 per kw-hr.



Plug-in type lamp provides off-on indication for this 115-v waffle iron. The lamp, rated at 2.5 v, is connected near one end of the resistive heating element to obtain the proper operating voltage.



Glow lamps are little affected by voltage changes, either in life or light output. Light produced by glow lamps is directly proportional to lamp current, while life is inversely proportional to, approximately, the cube of lamp current. Therefore, doubling the current will double light output, but will reduce life to one-eighth of normal. Useful life of argon lamps is less than that of neon lamps. Also, output of argon lamps for ultraviolet use drops to 50 per cent of its initial value after lamp operation of no more than one-third rated life. Although rated life of neon lamps may be as high as 50,000 hr, life of both neon and argon lamps for dc operation may be only 60 per cent of ac life.

To insure normal current through a glow lamp, a current-limiting series resistor must be used. Otherwise, current would "run away" and destroy the lamp. All screw-base glow lamps have resistors of the proper value built into the base. Other types must usually be equipped with a resistor external to the lamp.

Ambient Temperature Effects: Normal variation in ambient temperature does not affect the performance of miniature lamps. Above 350 F the solder on conventional lamps may soften, deform, or melt, and the basing cement may soften and loosen. Above 500 F, evolved gas may attack the filament, or the glass envelope may soften and collapse. Glow lamps are limited to a maximum of about 300 F.

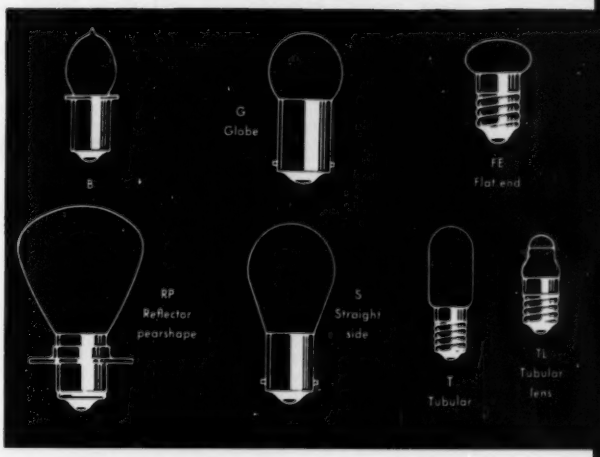


Fig. 1—Miniature-lamp bulb shapes.

In addition to extraneous heat, the effect of the lamp housing should also be examined for its effect on heat radiation, absorption, and ventilation.

Lamp Identification: Incandescent miniature lamps are identified completely by standardized designations issued by the American Standards Association. Glow lamps are designated by letter-number combinations common in the industry but not necessarily standardized.

Bulb shape and size and filament or electrode

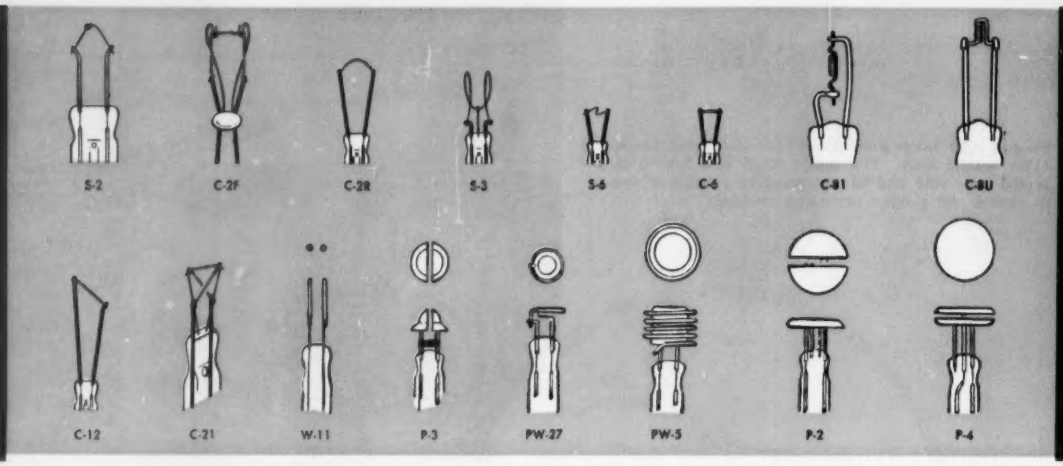


Fig. 2—Filaments and electrodes used in miniature lamps.

Selecting Miniature Lamps

configurations are identified by letter-number combinations, Fig. 1 and 2. Bulbs are measured through their greatest diameter in eighths of an inch. Thus, a G-6 bulb has a 6/8 or ¾-in. diameter globe shape. Lamp bases are usually identified by abbreviations as indicated in Fig. 3.

Some typical incandescent and glow lamps are listed in Tables 1 and 2.

Lamp Construction: Flange and butt-seal lamps are supplied with bases to protect the lead wires. Generally, lamps ¾ in. and larger are flange sealed; lamps less than ¾ in. diameter are butt sealed. Advantages of flange-seal construction are sufficiently heavy lead-in wires for currents up to 12 amp, accurately positioned filaments, and a stem construction that resists filament displacement and dam-

Table 1—Filament-Type Indicator and Appliance Lamps

Lamp Number	Bulb Type	Base Type	Design Volts	Current or Candlepower	Filament Type	Approx. Life (hr)	Light-Center Length (in.)	Max. Length Over-all (in.)
6	S-8	dc bay	6.40	3.00 amp	C-2R	500	1 1/4	2
8	S-8	dc bay	8.00	2.20 amp	C-2R	500	1 1/4	2
10	G-3 1/2	min 2-pin	2.50	0.50 amp	C-6	3000	5/8	15/16
40	T-3 1/4	min sc	6.3	0.15 amp	C-2R	3000	31/32	1 3/16
41	T-3 1/4	min sc	2.50	0.50 amp	C-2R	3000	31/32	1 3/16
43	T-3 1/4	min bay	2.5	0.50 amp	C-2R	3000	25/32	1 3/16
44	T-3 1/4	min bay	6.3	0.25 amp	C-2R	3000	25/32	1 3/16
46	T-3 1/4	min sc	6.3	0.25 amp	C-2R	3000	31/32	1 3/16
47	T-3 1/4	min bay	6.3	0.15 amp	C-2R	3000	25/32	1 3/16
51	G-3 1/2	min bay	7.5*	1 cp	C-2R	1000	1/2	15/16
67K	G-6	cand sc	13.5	4 cp	C-2R	1500	1	1 3/8
233	FE-3 3/4	min sc	2.25	0.25 amp	C-6	5	21/32	13/16
1224K	G-6	cand sc	32.0	3 cp	C-2F	200	7/8	1 3/8
1829	T-3 1/4	min bay	28.0	0.07 amp	C-2F	1000	5/8	1 3/16

*Circuit volts, 6 v.

Table 2—Data for Typical 110-125-v Neon Lamps

Lamp Number	Bulb Type	Base Type	Power Used (w)	Series Resistor (ohm)	Rated Life (hr)	Max. Length Over-all (in.)	Suggested Use
NE-2	T-2	wire term.	1/25	200,000	50,000 avg	1 1/16	Indicator
NE-2B	T-2	wire term.	1/10	62,000	5,000 min	3/4	Indicator
NE-2E	T-2	wire term.	1/10	62,000	5,000 min	3/4	End-on indicator
NE-2H*	T-2	wire term.	1/4	25,000	5,000 min	3/4	High output indicator
NE-30	S-11	med sc	1	7,500	10,000 avg	2 1/4	Illumination
NE-40	S-14	med sc	3	2,200	10,000 avg	3 1/2	Marker
NE-51	T-3 1/4	min bay	1/25	200,000	15,000 avg	1 3/16	Replaceable indicator
NE-51H*	T-3 1/4	min bay	1/4	25 000	5,000 min	1 3/16	High output indicator
NE-57	T-4 1/2	cand sc	1/4	30,000	7,500 avg	1 17/32	Dc indicator
NE-79	S-7	dc bay	1	7,500	10,000 avg	2	Indicator under vibration

*Designed for 110-125 v ac circuits. For dc circuits, a minimum of 150 v should be used.

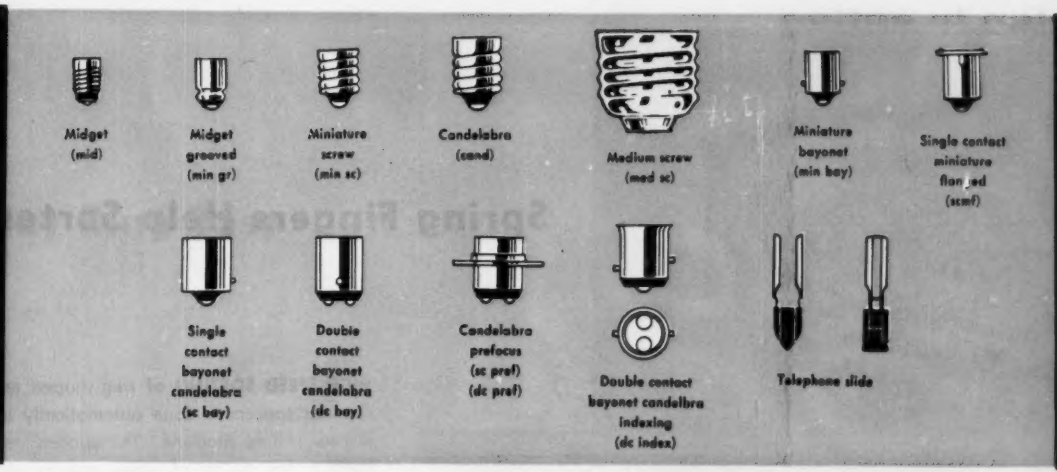

Midget (mid)
Midget grooved (min gr)
Miniature screw (min sc)
Candelabra (cand)
Medium screw (med sc)
Miniature bayonet (min bay)
Single contact miniature flanged (scmf)
Single contact bayonet candelabra (sc bay)
Double contact bayonet candelabra (dc bay)
Candelabra prefocus (sc pref) (dc pref)
Double contact bayonet candelbra indexing (dc index)
Telephone slide

Fig. 3—Base styles for miniature lamps.

age from shock and vibration.

In butt-seal construction the glass seal is very fragile. The lead-in wire may break off or a tiny air leak may develop at the seal point of the lead-in wire. Butt-seal lamps are restricted to relatively small wire sizes with a current limit of about 0.8 amp. Filament position varies considerably. Advantages are low cost and small size.

In a bulb of pinch-seal construction the glass is pinched or formed around the lead-in wires. All the small wire-terminal glow lamps and some incandescent types are made in this way. Bulbs for the smaller glow lamps are exhausted and tipped off at the end opposite the lead-in wires. Advantages of pinch-seal construction are low cost, small size, and no need for a conventional base.

Tips and Techniques

Square Root of $(c^2 - b^2)^{1/2}$

When the square root of the difference of two squares, $N = (c^2 - b^2)^{1/2}$, must be found often, the following tabular method is useful. For values of $c \geqq b$, $N = c[1 - (b/c)^2]^{1/2}$. Letting $M = [1 - (b/c)^2]^{1/2}$, $N = Mc$. Values of M for various b/c ratios can be calculated and listed in tabular form as shown.

b/c	M	b/c	M	b/c	M	b/c	M
0.01	1.000	0.26	0.966	0.51	0.860	0.76	0.650
.02	1.000	.27	.963	.52	.854	.77	.638
.03	1.000	.28	.960	.53	.848	.78	.626
.04	0.999	.29	.957	.54	.842	.79	.613
.05	.999	.30	.954	.55	.835	.80	.600
.06	.998	.31	.951	.56	.828	.87	.586
.07	.998	.32	.947	.57	.822	.82	.572
.08	.997	.33	.944	.58	.815	.83	.558
.09	.996	.34	.940	.59	.807	.84	.542
.10	.995	.35	.937	.60	.800	.85	.527
.11	.994	.36	.933	.61	.792	.86	.510
.12	.993	.37	.929	.62	.785	.87	.493
.13	.992	.38	.925	.63	.777	.88	.475
.14	.990	.39	.921	.64	.768	.89	.456
.15	.989	.40	.917	.65	.760	.90	.436
.16	.987	.41	.912	.66	.751	.91	.414
.17	.985	.42	.908	.67	.742	.92	.392
.18	.984	.43	.903	.68	.733	.93	.368
.19	.982	.44	.898	.69	.724	.94	.341
.20	.980	.45	.893	.70	.714	.95	.312
.21	.978	.46	.888	.71	.704	.96	.280
.22	.976	.47	.883	.72	.694	.37	.243
.23	.973	.48	.887	.73	.683	.38	.199
.24	.971	.49	.872	.74	.673	0.99	.141
0.25	0.968	0.50	0.866	0.75	0.662	1.00	0.000

When a square root is required, the value of M for the right b/c ratio is selected from the table and multiplied by c. — E. W. JENKINS, *Knolls Atomic Power Laboratory, Schenectady, N. Y.*

EDITOR'S NOTE

A similar method for finding the square root of the sum of two squares is described in MACHINE DESIGN, p. 82, Dec. 25, 1958.

Bend Allowance

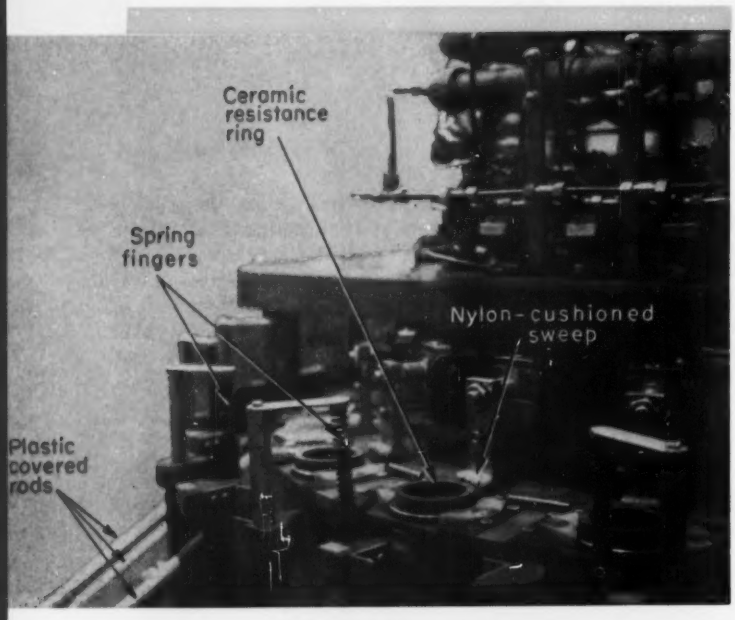
To find the approximate length of straight stock (either round or flat) required to make a bend, use the following formula:

$$L = \theta(0.01743R) + (0.0078t)$$

where L = length, in.; θ = angle of bend, deg; R = inside radius of bend, in.; and t = thickness of material, in.—HARVEY L. SHEELEY, *Northwest Equipment Co., Yakima, Washington.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

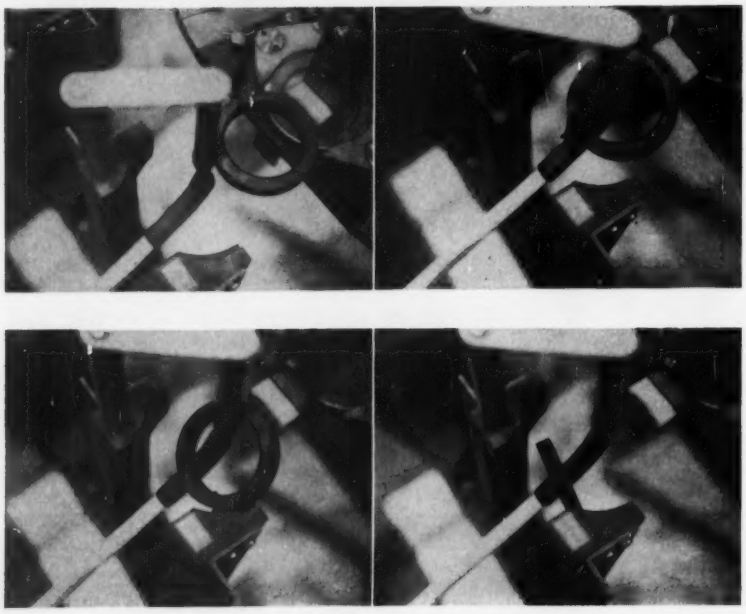
Spring Fingers Help Sorter



HIGH-SPEED SORTING of ring-shaped resistance spacers is done automatically in a new testing machine. The spacers are used in the design of series gap assemblies in station-type lightning arresters.

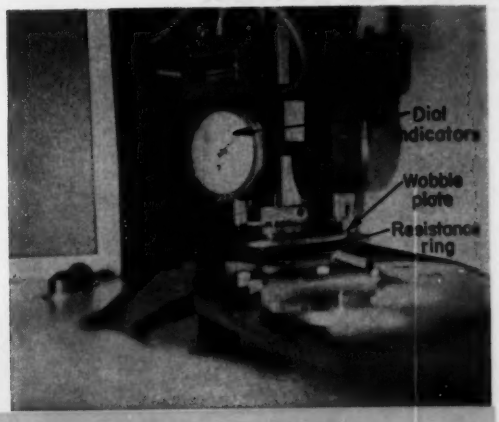
The Westinghouse Electric Corp. in conjunction with Industrial Instrument Inc., designed and built the machine to test and sort ceramic resistance spacers at the rate of 1800 per hour. According to E. L. Mallick, superintendent of quality control at the Westinghouse Distribution Apparatus Dept., Bloomington, Ind., the machine eliminates rebuilding gap assemblies because of problems caused by unmatched resistance spacers. In such units, it is desirable to keep all resistance spacers evenly matched both in height and resistance valve.

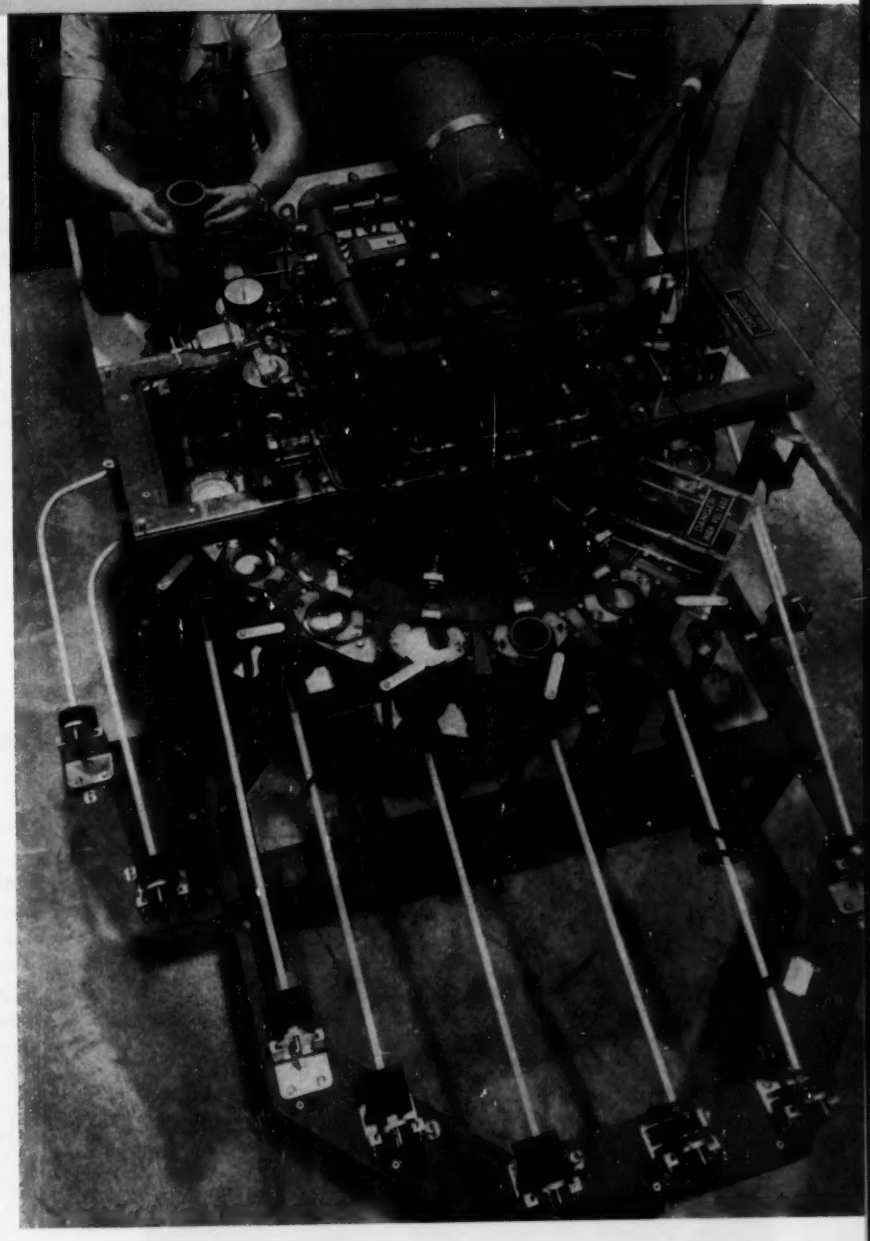
Sorting is a problem since the spacers are quite brittle, somewhat abrasive, and cannot be marked with any conducting material which would cause flashover at high voltages.



NYLON-CUSHIONED SWEEPS, attached to arms on airmotor cylinders, push the rings off an intermittent-motion, revolving table onto an appropriate plastic-covered rod. A special spring finger is mounted at right angles at the end of each rod. As the resistance ring comes in contact with the spring, the leading side of the ring is deflected downward onto the rod. This sorting and storing technique prevents damaging or marking of the rings in any way.

Play Ring Toss





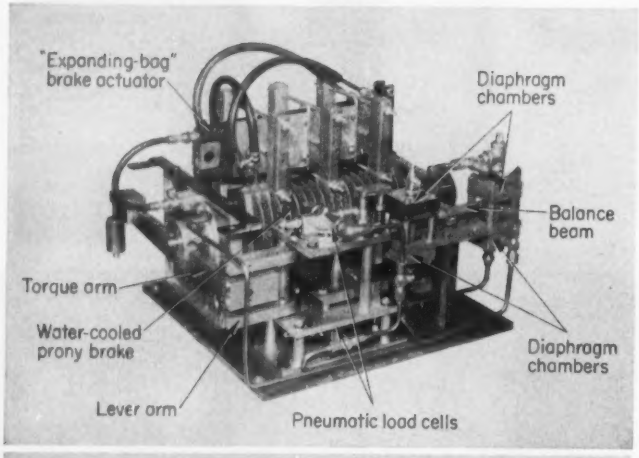
AUTOMATIC LOADING of the resistance spacers on the revolving sorting table is accomplished after the spacers are manually stacked in a vertical nonmetallic cylinder. A loading sweep transfers the bottom spacer from the cylinder to one of the test plates on the revolving table.

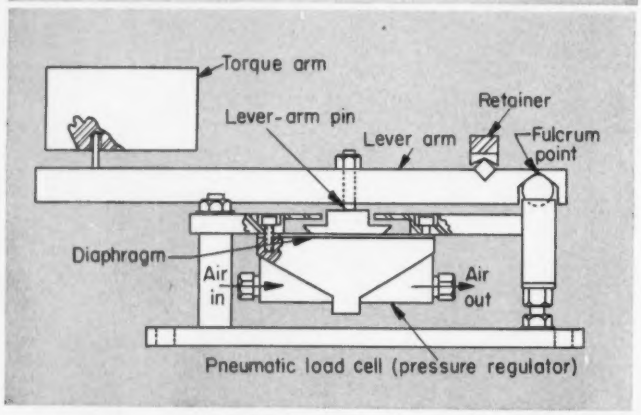
The table then indexes to the thickness measuring station which is an air-operated drilling head attached to a spring-loaded wobble plate. The wobble plate rests on top of the spacer. Three electrical dial indicators measure the distance from the top of the wobble plate to the test plate to detect any out-of-tolerance condition in the ring. The ring either passes or is swept onto the out-of-thickness-tolerance rod.

The next station applies 8000-volt ac on all remaining rings. Rejected spacers are swept onto the high-pot failure rod.

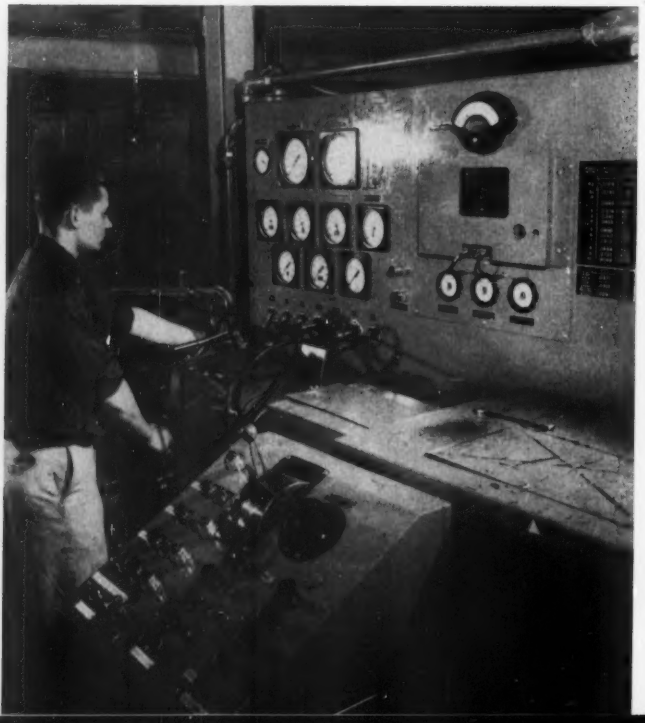
After this test, resistance values of the remaining rings are measured at 1200 volts dc. The spacers are sorted into seven groups over range of 2 to 3 megohms in 0.2-megohm increments.

Pneumatic Controls





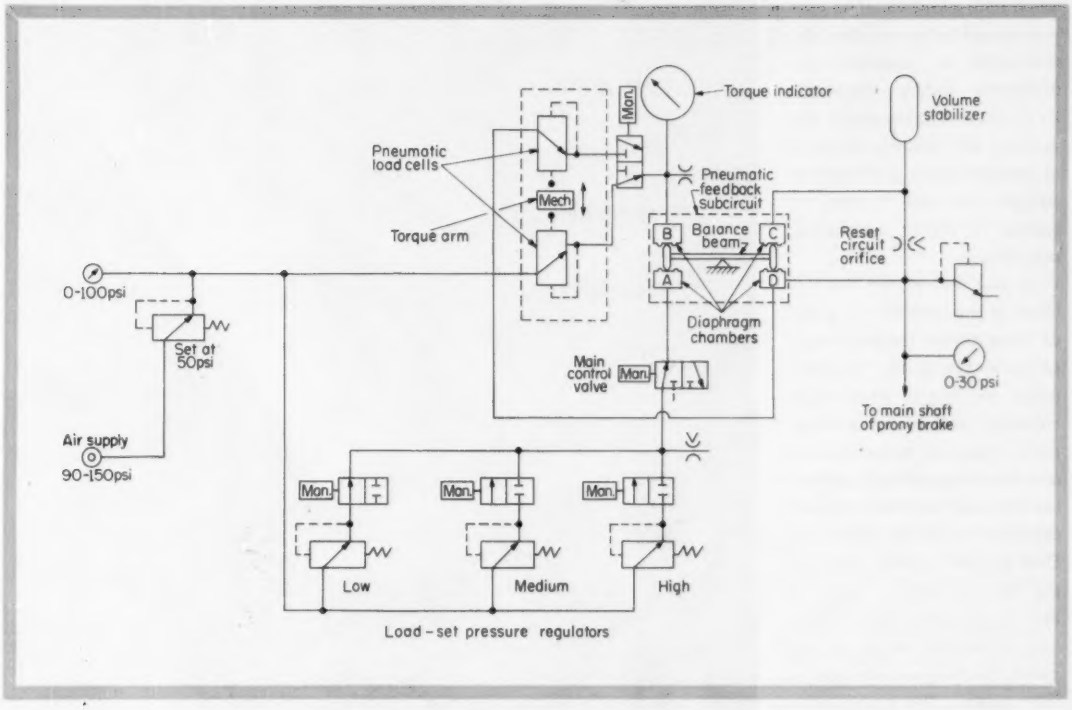
AUTOMATIC REGULATION of loading torque applied by an air-actuated prony brake centers around the operation of an air-modulated feedback control. Resembling an electrical Wheatstone bridge, the feedback control equalizes forces of four diaphragm pressure chambers, mechanically interconnected by a balance-beam assembly. In response to a set-point adjustment, the pneumatic bridge regulates pressure to an expanding-bag actuator on the prony brake. The end result is to hold a fixed torque on the unit under test.



PNEUMATIC PRONY BRAKE is part of a test stand designed and built by George L. Nankervis Co., Detroit, in co-operation with the Ford Motor Co. First use will be to production test Ford's new ten-speed tractor transmission.

"Wheatstone" Bridge

Prony-Brake Torque



THREE OUTPUT-TORQUE SETTINGS are checked on each transmission. Three load-set regulators are preset to pressures corresponding to torques applied by the prony brake. When the main valve and one of the three load-set pressure regulators are opened, air pressure in diaphragm chamber A of the feedback control subcircuit rotates the balance beam clockwise. This action opens the air valve in chamber D, sending air under pressure to the prony-brake actuator. Air also goes to chamber C through a restriction which dampens response of the system.

As the prony-brake shoes apply force to the internal shaft (coupled to the load), the torque arm applies a mechanical pressure to one of the two pneumatic load cells, depending on direction of rotation. The appropriate load cell sends a signal pressure, which is proportional to the torque arm force, to the torque-reading pressure gage and chamber B. Pressure in chamber B opposes the set pressure applied to chamber A.

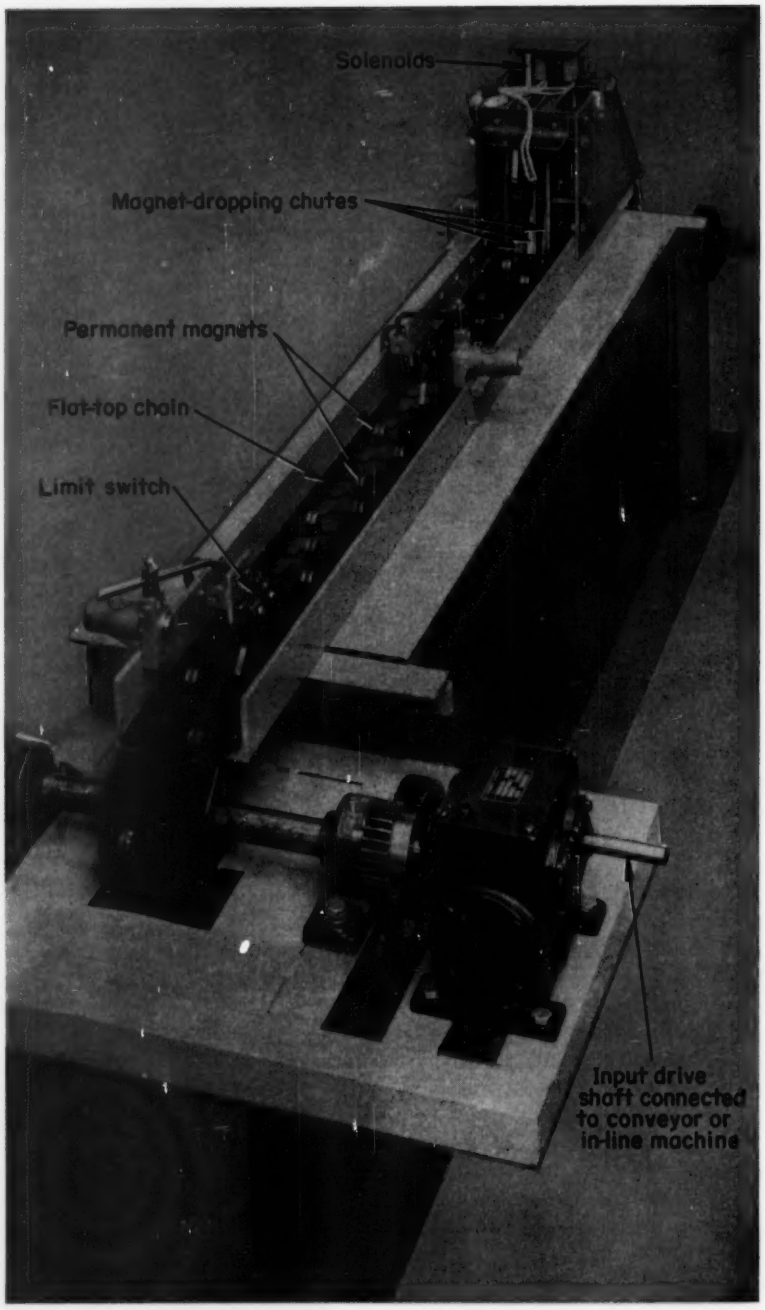
When the torque signal in chamber B equals the set pressure in chamber A, the system is in balance and the valve in chamber D closes. On the other hand, if the torque signal pressure exceeds the set pressure, the valve in chamber D bleeds off the brake operating pressure until balance is restored.

Air pressure in chamber C opposes the brake operating pressure in chamber D. Operating through a reset circuit orifice and volume stabilizer, pressure in chamber C critically damps the feedback subcircuit for optimum response with minimum overshoot.

Magnets Dropped on Chain Memorize Identity of Products

ELECTROMECHANICAL SEQUENCE CONTROLLER consists of a flat-top chain, small permanent magnets, and precision limit switches. The unit is designed to be mechanically connected to conveyors or automatic in-line machines. Its function is to memorize the location and identity of parts or products moving along in a straight line and, in turn, to control machine operations accordingly.

At one end of the flat-top chain in the controller is a set of three chutes holding small permanent magnets. In operation, any one of three chute solenoids can release a magnet in response to manual or automatic signals of product identity sent from the attached conveyor or in-line machine. Each magnet "locks" itself to the flat-top chain. After a time delay, when the product has advanced to a preset point, the magnet actuates a limit switch. This action energizes a power device which performs a desired function, such as reject, divert, fill, etc. When the magnet releases the limit switch, the power device, such as a motor or solenoid, is de-energized and reset. The magnets are returned by the chain to the solenoid-operated chutes where they accumulate for reuse.



THERMAL STRESSES IN DESIGN

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Part 13 — Incremental Solutions for Plastic Stresses and Strains

• Plastic Flow Formulations • Creep Formulations

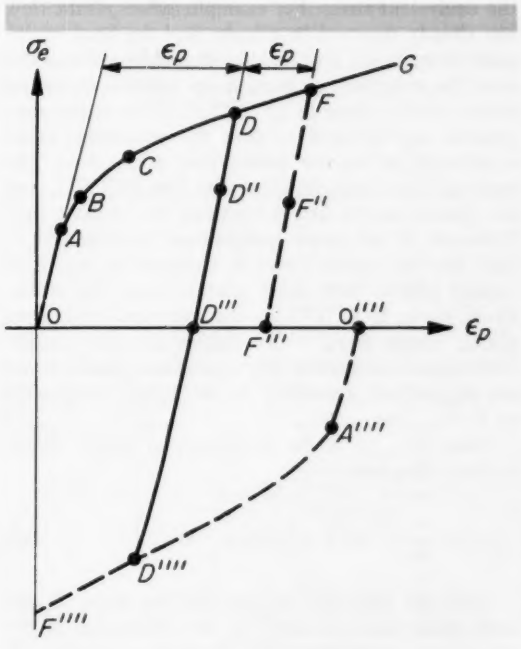


Fig. 75—Behavior of material during stress loading and unloading.

UNLOADING is a stress phenomenon which occurs when the stress is reduced at a point in a body which has previously undergone plastic flow. Under these conditions, the plastic strain persists and only the elastic strain is affected. Upon further loading by other stresses, there is no direct correlation between a specific stress and the total strain. Therefore, the deformation theory cannot be used to solve these problems, since the conditions of continuous loading and constant stress state are not present.

This article discusses the incremental theory of plasticity and how and when it is applied to thermal-stress solutions.

When there is no longer a direct correlation between a specific stress and a given strain, the final strain can best be determined only if the complete history of stress, and not simply the final stress, is considered. Even when no unloading occurs, a complication arises if the history of the material includes changes in the stress state—that is, changes in the ratio of principal stresses. As long as the stress state remains unchanged, specification of the final stress distribution essentially indicates the complete history of stress distribution. However, if the stress-state history is variable, the stress distribution at any time does not give an indication of the stress-state history. This is true even if unloading does not occur.

In many cases of thermal loading a transient temperature history, involving plastic flow with unloading, occurs in some regions of the body before the final temperature distribution is achieved. Even at a steady temperature, the action of creep produces a constantly changing stress distribution which usually involves changes in the stress state and unloading in some regions of the body.

Plastic Flow Formulations

To use the basic equations for incremental theory, it is desirable to review the behavior of a material as it is loaded and unloaded after the material has been stressed beyond the yield points at least once. Uniaxial stress is considered first, followed by a discussion of biaxial and triaxial stresses.

Uniaxial Stress: In Fig. 75, the stress-strain curve of a material is shown at the line *OABCDF*. If the material is uniaxially loaded or unloaded so that the yield stress *A* is never exceeded, the material remains elastic and all loading and unloading proceeds along line *OA*. In addition, complete unloading always returns the material to its initial state *O* regardless of the history of loading and unloading. However, if the material is continuously loaded until the stress at *D* is reached and is then unloaded, unloading does not reverse the path *DCBAO* but takes the path *DD"D"'*. If the stress is reduced to *D"* and is increased again, the stress is *D"DF*. Under these conditions the material acts as a new material having a yield point of *D* and a stress-strain curve of *D"'D"DF*.

It is usually assumed that the material has the same stress-strain curve in compression as in tension. Also, alteration of the stress-strain curve due to plastic flow is assumed the same in both compression and tension. Thus line *O""A""D""* represents the initial stress-strain curve in compression with the strain origin shift to *O""* while *D"'D""F""* represents the compressive curve after the material has once been subjected to a tensile or compressive stress of *D*.

Thus, for a uniaxially loaded material subjected to a plastic flow ε_p, Fig. 75, the strain at any subquent stress σ, regardless of whether it is loaded or unloaded further, is

$$\varepsilon = \varepsilon_p + \frac{\sigma}{E} + \varepsilon_p' \tag{93}$$

where ε_p' = any new plastic flow. Whether or not new plastic flow takes place depends on the final stress and the new stress-strain curve *D"'D"D*. If the stress goes to σ_F the increment in plastic strain is ε_p'. If it goes only to *D"* there is no further plastic strain, even though σ_D" is sufficient to cause plastic strain in the initial condition of the material prior to the plastic strain ε_p.

Biaxial Stress: Although the foregoing approach is useful in uniaxial problems which involve unloading, it is most advantageous in biaxial and triaxial problems.

When multiaxial stresses are present, the criterion for further plastic flow is the increase or decrease in the equivalent stress. For example, when plastic flow has already occurred in a body, and the final equivalent stress is σ_D, Fig. 75, the material at that point must be regarded as having an equivalent stress-strain relation given by *D"'D"DF*. If the stress components are changed so that the equivalent stress is reduced, no further plastic flow takes place. The material then unloads along the line *DD"D"'*, and the elastic strains are determined by Hooke's law. However, if the stress components are changed so that the equivalent stress is increased to σ_F, then further plastic flow takes place. Since the stress-strain curve is *D"'D"DF*, the increased equivalent plastic strain is ε_p'. The individual plastic-strain components comprising this equivalent plastic strain are determined according to the stress components at *F*, $\sigma_{F,x}$, $\sigma_{F,y}$, $\sigma_{F,z}$.

Thus, if $\varepsilon_{p,x}'$ is the increment of plastic strain in the *x*-direction,

$$\varepsilon_{p,x}' = \frac{\varepsilon_p}{\sigma_F}\left[\sigma_{F,x} - \frac{1}{2}(\sigma_{F,y} + \sigma_{F,z})\right] \tag{94}$$

Once the material has reached the stress *F*, the total component of strain in the *x*-direction is obtained by considering: 1. Thermal expansion. 2. Elastic strain. 3. All prior plastic strains during the initial history leading to the stress state at *D*. 4.

Nomenclature

E = Modulus of elasticity, psi
K = Constant
R = Universal gas constant
r = Radius, in.
T = Temperature, F
ΔT = Change in temperature, F
t = Time, sec
Δt = Time increment, sec
α = Coefficient of expansion, in./in./deg F
ε = Strain, in. per in.
$\Delta\varepsilon$ = Incremental strain, in. per in.
μ = Poisson's ratio
ρ = Density, lb-sec^2/ft^4
σ = Stress, psi
ω = Angular velocity, rad per sec

Subscripts:

c = Creep
e = Equivalent
m, n = Constants
p = Plastic
r = Radial
t = Total
x, y, z = Directions
θ = Tangential
0 = Initial

Increase in plastic strain as the material passes from D to F. If the plastic strain at D which results from any complex history of stress up to that point is $\sum_{0}^{D} \varepsilon_{p,x}$, then the total strain at F is

$$\varepsilon_{F,x} = \alpha T + \frac{\sigma_{F,x} - \mu(\sigma_{F,y} + \sigma_{F,z})}{E} + \sum_{0}^{D} \varepsilon_{p,x} + \frac{\varepsilon_p'}{\sigma_F}\left[\sigma_{F,x} - \frac{1}{2}(\sigma_{F,y} + \sigma_{F,z})\right] \quad (95)$$

where σ_F = the equivalent stress corresponding to the components $\sigma_{F,x}$, $\sigma_{F,y}$, *and* $\sigma_{F,z}$, and ε_p' = the equivalent strain corresponding to the components $\varepsilon_{p,x}'$, $\varepsilon_{p,y}'$, and $\varepsilon_{p,z}'$. Because each step in the process consists of obtaining the increment in plastic strain as the material passes from one stress state to the next, the procedure is known as the incremental approach.

Once the plastic strains have been determined at F, changes in the stress state in the vicinity of F are considered. For example, a change in the stress components to increase the equivalent stress to σ_G at point G produces a new plastic strain component which is obtained by using Equation 95. Where F is replaced by G. The plastic strain components between D and F are incorporated with the summation term in the equation. Hence, the limits for this term become O to F.

A simple application of Equation 95 to a material subjected to stress increases, when the stress components are in constant proportion, gives the same results obtained by the deformation approach. Application of Equation 95 becomes more significant as the change in stress ratio increases as the stresses are changed. It is of greatest significance if unloading occurs at any point in the process.

Total Equivalent Strain: If the summation term in Equation 95 is transposed to the left hand side of the equation it becomes analogous to Equation 78.[11] The expression $\varepsilon_x - \Sigma\varepsilon_{p,x}$ is the total strain component in the x-direction due to the temperature and stresses, which takes into account the change in the free length of the element induced by plastic flow. If this expression is denoted by the term *corrected total-strain component* then an equivalent, corrected total strain can be constructed from the components in an analogous manner to Equation 79. This strain will be related to the increment in plastic strain by Equation 80. This observation makes it possible to perform any one computation in the manner used for deformation-theory computation.

Creep Formulations

Solution of problems by incremental theory consists of several individual computations, each of which represents stage actually encountered by the body during its mechanical or thermal history. In any one computation, however, the procedure is the same as if deformation theory were used, and the special-techniques developed for deformation-theory solutions are used to advantage. The only difference between the two approaches is that each point must be regarded as having a different but known stress-strain curve which is dependent on the amount of plastic flow at that point which has occurred during prior computations.

To illustrate the procedure, a flat circular disc is subjected to thermal shock so that it undergoes a known history of temperature distribution. Computations are made for temperature distributions which occur at several time intervals after the initiation of the shock. In each computation the temperature distribution used is the one which occurs at the time chosen. The equilibrium equation involving the stresses only is the same as for elastic

[11]References are tabulated at end of article.

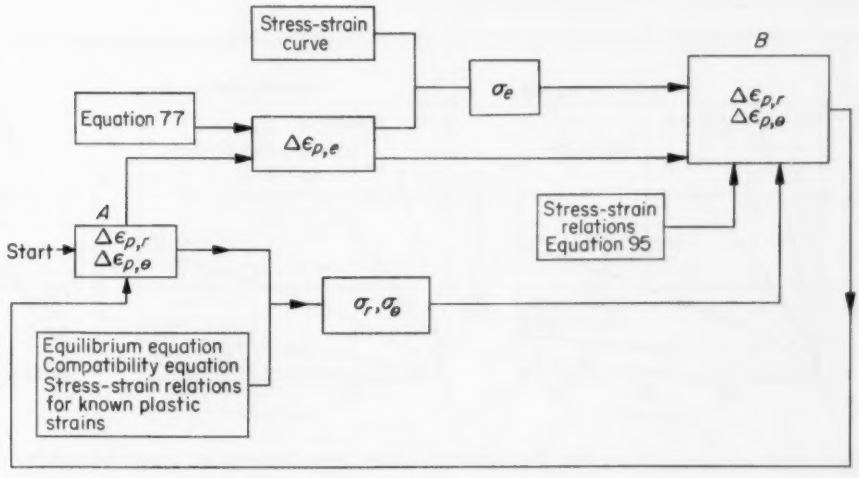


Fig. 76 — Block diagram for solution of plastic-flow problems by incremental theory.

computations, and the compatibility equations involving the total strains only are likewise the same. The total strain must include all the plastic strains accumulated for computations for prior temperature distributions.

Solution Procedure: Any method of successive approximations involves the assumption of certain quantities, and then, in some way, these quantities are computed from the equations that must be satisfied. If the computed values do not agree with the assumed values, new computations are made in which the values previously calculated become the new assumed values. When the calculated values equal the assumed values, the correct solution has been obtained. Obviously there are numerous starting assumptions and numerous continuation procedures that can be used. The total equivalent strain method[12] can be used by treating each step in the problem as a deformation-theory solution with altered stress-strain curves. Several other approaches can also be used.[13,14] The approach outlined here is one which has been used for both creep and plastic flow problems.[15]

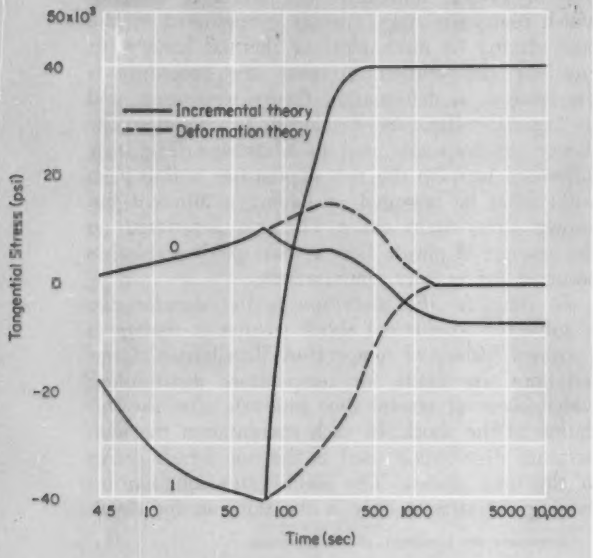


Fig. 77—Comparison of problem solution by incremental and deformation theories. Tangential stress at two radial positions in heated disc plotted against time.

1. Perform elasticity calculations at several successive points during the loading process, thermal alone or in conjunction with mechanical loading, to determine the conditions under which the equivalent stress at the highest stressed point exceeds the elastic limit. The first plastic flow computation should be made at conditions for which the yield point is exceeded at one or more stations. The nominal elastic stresses and strains provide the starting point for the first set of computations. From the value of σ_e at each station, compute a value of $\Delta\varepsilon_{p,e}$. Then using the elastic stresses and σ_e as determined from the elastic stresses, use Equation 77 to determine first estimates for $\Delta\varepsilon_{p,r}$ and $\Delta\varepsilon_{p,\theta}$.

2. The remaining procedure is indicated by the block diagram of Fig. 76. Using the estimated values of $\Delta\varepsilon_{p,r}$ and $\Delta\varepsilon_{p,\theta}$ and Equation 77, compute $\varepsilon_{p,e}$ which, together with the stress-strain curve, gives σ_e. Simultaneously, along an independent leg of the computation, use the estimated values of $\Delta\varepsilon_{p,r}$ and $\Delta\varepsilon_{p,\theta}$ together with the equilibrium and compatibility equations, to obtain σ_r and σ_θ. The solution may be obtained in closed form by finite-difference methods, or any other technique. Values of σ_r and σ_θ are then used with the value of σ_e, determined from Equation 95 to obtain new estimates of $\Delta\varepsilon_{p,r}$ and $\Delta\varepsilon_{p,\theta}$. These values in box B are then transferred to box A, and the procedure repeated until successive values for the plastic strains show no change.

3. Proceed to the new temperature and loading conditions. As before, the first computation is elastic, but takes into account the prior plastic flow

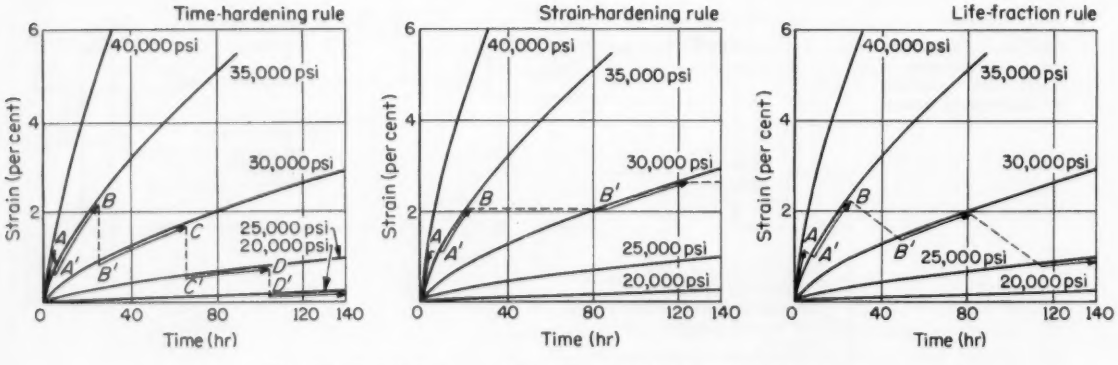


Fig. 78—Cumulative creep laws illustrated by hypothetical curves.

as permanent strains. Thus, use is made of Equation 95 and the summation expression, which is the plastic flow of the first computation in this case. However, the plastic strain terms are omitted. The new elastic stresses provide a basis for estimating the increments in plastic strain during the second interval, and the procedure of step 2 is repeated.

EXAMPLE: Fig. 77 shows the results of stress computations for an induction-heated disc in which an experimentally determined temperature history was used.[15] For comparison, the results of incremental theory and deformation-theory solutions are included. For the deformation approach, each computation was made on the basis of the temperature distribution at the time involved, without regard to prior plastic flow. As long as the loading increases without change, the two computations show no detectable difference. When unloading occurs wide differences are indicated. In design, deformation theory calculations should not be made during unloading without considering plastic flow. The logical procedure for this example would be to stop at 75 seconds when the unloading at the rim begins. Results of residual stress calculations[14] would not, in many cases, be very different from those obtained by incremental-theory computations. However, the incremental approach circumvents the judgment factors and includes the possibility of continued plastic flow in some portions of the body while others are unloading.

Creep Formulations

Creep problems are treated in a manner which is essentially similar to that used for plastic-flow problems. A series of computations are made, each at a progressively increasing time interval, after the initiation of loading. Each computation determines the increase in creep strain for each increment of time. Two important factors for the computations must first be postulated: Stress-strain-time relations in the case of combined stress, and cumulative creep laws in cases involving variable-stress history.

Stress-Strain-Time Relations: Although the incremental procedure is not limited by the shape of the creep curve, it is necessary to select a specific relation for illustration. If the stress is triaxial, it is assumed that an equivalent stress σ_e is formed according to Equation 74, and that an equivalent creep strain $\varepsilon_{c,e}$ is formed according to Equation 75. Also, for the simplest case, it is assumed that a power-law relationship exists between total time t, equivalent stress, and the equivalent strain. Thus,

$$\varepsilon_{c,e} = K \sigma_e^m t^n \tag{96}$$

For the time increment, Δt, the increment in equivalent creep strain is $\Delta\varepsilon_{c,e}$. Hence, Equation 96 becomes

$$\Delta\varepsilon_{c,e} = nk\sigma_e^m t^{n-1} (\Delta t) \tag{97}$$

Increments in the individual creep-strain components are assumed to bear the same relations to the stress component and the equivalent stress and strain as in incremental plasticity theory. For example,

$$\Delta\varepsilon_{c,r} = \frac{\Delta\varepsilon_{c,e}}{2\sigma_e} (2\sigma_r - \sigma_\theta - \sigma_z)$$

$$\Delta\varepsilon_{c,\theta} = \frac{\Delta\varepsilon_{c,e}}{2\sigma_e} (2\sigma_\theta - \sigma_r - \sigma_z)$$

$$\Delta\varepsilon_{c,z} = -\Delta\varepsilon_{c,r} - \Delta\varepsilon_{c,\theta} \tag{98}$$

Cumulative Creep Laws: Consider first a uniaxial stress in which the magnitude of the stress is varied during the test. If the stress is changed after a certain amount of creep at a given constant stress, the shape of the continuing strain-time path must be determined. The computation procedure used for this determination can be applied to any arbitrary law.

Three cumulative creep laws are shown in Fig. 78. The time-hardening rule states that the principal factor governing the creep rate is the time at the temperature involved regardless of the stress

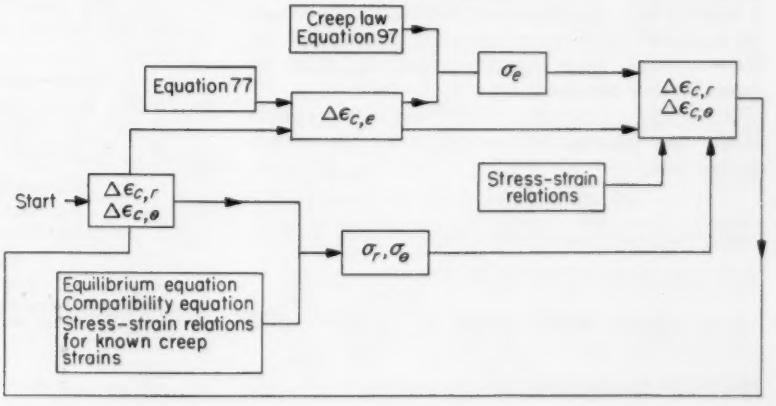


Fig. 79 — Block diagram for solution of plastic-creep problems by incremental theory.

history. Thus, if the stress, Fig. 78, is maintained at 40,000 psi for 5 hours, the initial creep curve is OA. If the stress is suddenly changed to 35,000 psi, and point A' is located vertically below A, and if, for the next 20 hours, the stress remains at 35.000 psi, continued creep occurs along $A'B$. If the stress is then changed to 30,000 psi, a new point B' is located vertically below B, and creep proceeds along $B'C$. If t_0 represents the time at the beginning of a creep interval, Equation 97 is solved for σ_e by replacing the time, t, by the average time, $t + (\Delta t/2)$, during the interval Δt:

$$\sigma e = \left[\frac{\Delta \varepsilon_{e,c}}{nK(\Delta t)} \right]^{1/m} \left[t + \frac{(\Delta t)}{2} \right]^{(1-n)/m} \qquad (99)$$

For strain hardening the assumption is made that the principal factor governing the creep rate is the strain regardless of the stress history required to produce the strain. Thus, under a variable-stress history, initial points on new stress curves are obtained by proceeding along horizontal lines, Fig. 78. To obtain the relation between the stress, strain, and strain increment, time is eliminated from Equations 96 and 97. Thus, if $\varepsilon_{e,c,o}$ is the equivalent creep strain at the beginning of interval Δt during which the stress changes to σ_e, and if $\Delta \varepsilon_{e,c}$ is the increment of equivalent creep strain during the interval,

$$\sigma_e = K^{-1/m} \left[\frac{\Delta \varepsilon_{e,c}}{n(\Delta t)} \right]^{n/m} \left(\varepsilon_{e,c,0} \right)^{(1-n)/m} \qquad (100)$$

The life-fraction rule is a compromise between the time and strain-hardening rules. If the strain, Fig. 78, creeps up to point B at 35,000 psi, and if the stress is then changed to 30,000 psi, the point B' is located such that the time at B' is the same fraction of the total life at a steady 30,000 psi as the time at B is for a steady stress of 35,000 psi. Thus, if the time at B is $\frac{1}{4}$ the total life of a steady stress test at 35,000 psi, B' is chosen at $\frac{1}{4}$ the life along the 30,000 psi curve.

Solution Procedure: To illustrate the procedure, let $\varepsilon_{r,c,o}$ and $\varepsilon_{\theta,c,o}$ be the creep strains at time t_0 in a rotating disc. It is assumed that these values have been determined by prior computation, and that the increments of creep strain, $\varepsilon_{r,c}$ and $\varepsilon_{\theta,c}$ must be found for time increment Δt.

If $\varepsilon_{r,c}$ and $\varepsilon_{\theta,c}$ are the total strains at the middle of the time interval, and σ_r and σ_θ are the stresses at this time,

$$\varepsilon_{r,c} = \frac{1}{E}(\sigma_r - \mu\sigma_\theta) + \alpha T + \varepsilon_{r,c,0} + \frac{1}{2}\Delta\varepsilon_{r,c}$$

$$\varepsilon_{\theta,c} = \frac{1}{E}(\sigma_\theta - \mu\sigma_r) + \alpha T + \varepsilon_{\theta,c,\theta} + \frac{1}{2}\Delta\varepsilon_{\theta,c} \qquad (101)$$

Hence, the compatibility equation becomes

$$\frac{d}{dr}\left(\frac{\sigma_\theta}{E} - \frac{\mu\sigma_r}{E} + \alpha T + \varepsilon_{\theta,c,0} + \frac{\Delta\varepsilon_{\theta,c}}{2}\right) = \frac{1+\mu}{E}\left(\frac{\sigma_r - \sigma_\theta}{r}\right) + \frac{\varepsilon_{r,c,0} - \varepsilon_{\theta,c,0}}{r} + \frac{\Delta\varepsilon_{r,c} - \Delta\varepsilon_{\theta,c}}{2r} \qquad (102)$$

Also, the equilibrium equation becomes

$$\frac{d}{dr}(rh\sigma_r) - h\sigma_\theta + pw^2r^2h = 0 \qquad (103)$$

For this solution, it is first necessary to establish the creep curves at different temperatures and stresses. Thus K, m, and n, in Equation 96 must be determined for each station in the disc. Since the creep curves[16] at a given stress but different temperature can be brought into coincidence if

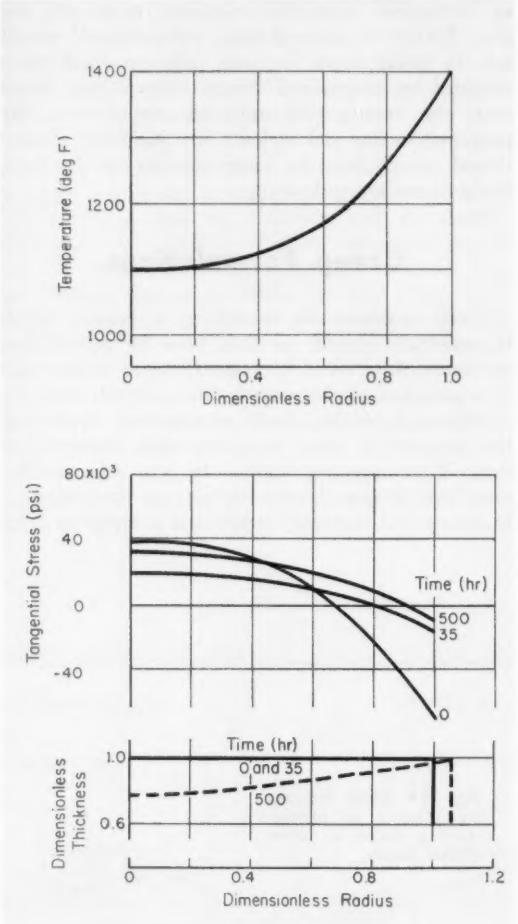


Fig. 80—Stress variation due to creep in rotating disc with radial temperature gradient.

creep is plotted against $te^{-\Delta H/RT}$, Equation 96 becomes

$$\varepsilon_{\theta,c} = K\sigma_e^m[te^{-(\Delta H)/RT}]^n$$

$$= K'\sigma_e^m t^n \qquad (104)$$

The constants m and n are the same for all stations, but the coefficient $K' = Ke^{-n\Delta H/RT}$ varies from station to station if the temperature varies. If K,m, and n are determined from a series of tests at one temperature, and ΔH from creep tests at a constant stress and several selected values of temperature, K' is readily determined. If an experimentally determined relation for K in terms of temperature is known, it can be directly applied.

The elastic or plastic stresses in the disc are first computed without regard for creep. Presumably this stress distribution is developed at the instant the loading is applied, $t = 0$, when the time-dependent creep has not yet occurred. It is then possible to proceed to the first time interval. The size of this interval depends on the particular problem. The important considerations are that the computation be convergent, and that the stress change be kept small in any one interval.

The next step is to estimate the creep increments during the first interval. Actually the estimations are not critical, since subsequent iterations quickly tend toward the correct values. However, since the number of iterations required for convergence depends on the correctness of initial estimates, the following procedure may be used for the creep estimates:

1. As a first approximation, assume that the stresses do not change during the time interval chosen, and that σ_r, σ_z, and σ_e are known from the elastic or plastic computation.
2. Use the value of σ_e together with Δt in Equation 97 to obtain the equivalent creep strain $\Delta\varepsilon_{e,c}$ during the interval.
3. Use Equation 77 together with the equivalent creep strain and the stresses to obtain $\Delta\varepsilon_{\theta,c}$ and $\Delta_{r,c}$.
4. Use the procedure indicated in the block diagram, Fig. 79, for the remainder of the solution.

Once the values of $\Delta\varepsilon_{r,c}$ and $\Delta\varepsilon_{\theta,c}$ are estimated, they are substituted into Equation 101, 102 and 103. These equations become linear differential equations, and are solved for σ_r and σ_θ in closed form by finite differences, or any other convenient method.

Simultaneously, the values of $\Delta\varepsilon_{r,c}$ and $\Delta\varepsilon_{\theta,c}$ are combined with Equation 77 to obtain the equivalent strain which, through the use of Equation 97, yields the equivalent stress, σ_e. If this procedure is used to estimate the creep strains, values of σ_e revert to the elastic or plastic stresses for the first iteration, and the first part of the flow chart is needed only for calculating subsequent iterations.

Next, the values of σ_r, σ_θ, σ_e and $\Delta\varepsilon_{e,c}$ are used in conjunction with the stress-strain relations, Equation 95, to compute new values of $\Delta\varepsilon_{c,r}$ and $\Delta\varepsilon_{c,\theta}$. If these values do not agree with the initially assumed values, the new values are used as a starting point and the procedure is repeated until agreement is obtained.

For initial estimates of $\Delta\varepsilon_{r,c}$ and $\Delta\varepsilon_{\theta,c}$ in the second interval, assume that the creep rates established in the first time interval are carried into the second. Hence, the creep strains in the second interval are obtained from those in the first by direct proportionality of the size of the time intervals. The remaining procedure is identical to that previously outlined.

The procedure is repeated for all subsequent time intervals. The size of the interval may be increased if it is found that the stresses no longer change rapidly. Calculation results from prior intervals are used as a guide in selecting the interval size which will limit the stress changes by some arbitrary amount. When the stresses no longer change, a steady-state creep has been established, and the criterion of interval size can be the amount of creep strain per interval. In fact, no further calculations are needed if dimensional changes due to creep do not affect the loading.

EXAMPLE: Fig. 80 shows the results of creep calculations for a disc with a given temperature distribution. The tangential stress starts with a high compressive component at the rim due to the thermal stress, but this stress is quickly relaxed due to creep. The stress at the center starts at about 40,000 psi, but is relaxed to about 20,000 psi as the strains due to thermal stress and the initial centrifugal stress are more evenly distributed throughout the disc by creep. The figure also indicates, to an exaggerated scale the changes in disc contour. At the start it is of uniform thickness, but after 500 hours, the thickness at the center is considerably reduced while the radius is increased. The increasing centrifugal force due to increases in the diameter, and the decreasing load-carrying capacity due to thickness reduction, leads, in time, to an instability which causes the disc to burst.

The next article in this series will discuss the various methods used for measuring thermal stresses, and how the results are interpreted.

REFERENCES

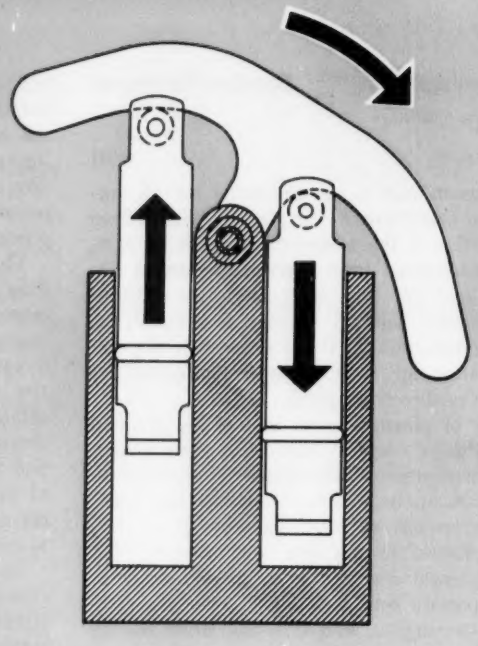
This article is the thirteenth in a series by S. S. Manson on thermal stresses in design. Previous articles and issues of MACHINE DESIGN in which they appeared are:

1. "Appraisal of Brittle Materials" ..... June 12, 1958
2. "Quantitative Techniques for Brittle Materials" .. June 26, 1958
3. "Basic Concepts of Fatigue in Ductile Materials" ..... August 7, 1958
4. "Causes of Fatigue in Ductile Materials" ..... August 21, 1958
5. "Interpretation of Fatigue Data for Ductile Materials" ..... September 4, 1958
6. "Elastic Stress Analysis" ..... January 22, 1959
7. "Exact and Approximate Solutions" ..... February 5, 1959
8. "Elastic Stresses by Energy Methods" ..... February 19, 1959
9. "Elastic Stress Solutions" ..... March 5, 1959
10. "Elastic Stresses by Minimizing Residuals" ... March 19, 1959
11. "Stresses Under Plastic Flow and Creep" ..... July 9, 1959
12. "Plastic Stresses and Strains by Successive Approximations" ..... July 23, 1959

Other reference mentioned in this article are:

13. M. B. Millenson and S. S. Manson—"Determination of Stresses in Gas Turbine Disks Subjected to Plastic Flow and Creep," *NACA Report No.* 906, 1948.
14. Roger S. Hanson—*Solutions of Two Plasticity Problems by the Deformation and Incremental Theories*, Ph.D. Dissertation, Iowa State College, 1958.
15. A. Mendelson, M. H. Herschberg, and S. S. Manson—"A General Approach to the Practical Solution of Creep Problems," Paper No. 58-A-98, ASME Transaction, *Journal Basic Engineering*, 1958.
16. J. E. Dorn and L. A. Shepard—"What We Need To Know about Creep," *ASTM Special Publication*, No. 165, 1954, p. 3-30.

Involute cam principle is adaptable to widely varying requirements.



TWO single-acting pistons and a symmetrical involute-cam rocker arm are principal elements in a versatile new hydraulic actuator. The design is adaptable to any fluid-powered mechanism requiring torque transmission through oscillation of less than one-half revolution. Backlash is eliminated; no rotary high-pressure seals are used.

Four unique advantages of the design are:

1. Pressure angle is zero throughout the full range of motion because the point of contact on the cam follower is always in line with the axis of force application. Thus, there is no side-loading on the pistons, short strokes do not require long pistons, and seals wear evenly. Also, large force applications do not require correspondingly large cam sizes.
2. Angular motion is directly proportional to linear motion at all times. When the piston travels one unit (linear), the resulting cam rotation is one unit (angular) whether at the middle or at the extreme end of stroke. In a closed-loop control system this feature allows a simple rectilinear potentiometer to be attached to the cam follower shaft to feed back rotational position of the rocker arm.
3. Torque-force relationship is constant throughout the full range of motion. Unlike a crank and connecting-rod, the effective moment arm is unchanging. Force available to overcome inertia for starting or reversing is the same in any part of the stroke.
4. Design simplicity makes this actuator much less expensive to produce than many conventional types. Close tolerances and metal-to-metal seals are unnecessary, and a high order of reliability is assured.

Involute Cam Surface: Advantages of this actuator design result from the involute shape of the cam surfaces. An involute may be described as a curve traced by the end of a taut string as it is wound upon or unwound from another curve. In this case a right circular cylinder is used as the basic curve form, Fig. 1.

If the direction of a force coincides with the free portion of the string, *BP*, it will always be perpendicular to the curve at any point because slope of a curve is always perpendicular to radius of curvature. This is the basis of the statement about zero pressure angle.

If piston stroke is the same as the length of free portion of string, the stroke will also be a simple linear function of angle ψ from the x-axis to the end of the string tangent to the cylinder. Therefore, the statement that angular and linear motions of the actuator are always directly proportional is true.

Angular motion is limited to approximately 135 degrees; otherwise, one end of the rocker arm will begin to pass through the cylinder of the retracted piston.

Design Procedure: Before an actuator design is undertaken, it is reasonable to assume that at least three things will be known:

1. Hydraulic pressure differential between pistons.
2. Required torque output.
3. Angle of oscillation.

Values for these conditions can vary widely. For instance, in an aerodynamic control-surface actuator with restricted packaging envelope the angle of oscillation might be small, torque might be large, and pressure could be the same as that of the main sys-

New ideas for designing

Rotary Hydraulic Actuators

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tem used throughout the vehicle. In an airborne radar actuator requiring large total deflection the torque output for sufficient stiffness might be small, and hydraulic pressure in the medium range could be provided by a tiny auxiliary power supply. In a piece of earth-moving machinery all numbers might be large. In an instrument or indicating device, maximum oscillation with minimum power might be desired.

With the three conditions known, a whole family of actuator configurations can be created, each satisfying the same requirements, but with all dimensions expressed in terms of a single parameter—the area of one of the twin hydraulic pistons.

Geometry involved in design analysis is shown on the left side of the symmetrical rocker arm in Fig. 2. A roller cam follower, one of the twin pistons, and a cross-sectioned cylinder are represented on the right side. A straight-through camshaft, with the type of rocker arm shown, limits maximum piston diameter because some space must be allowed for the camshaft between pistons. Maximum piston diameter can be expressed entirely in terms of known values of pressure, torque, and angle.

Basic relationships for actuator force and evolute, or base circle, radius are (see Nomenclature)

$$F = Pa \tag{1}$$

$$T = FR \tag{2}$$

Combining,

$$R = \frac{T}{F} = \frac{T}{Pa} \tag{3}$$

Nomenclature

a = Piston area (single), sq in.
D = Piston diameter, in.
F = Piston force (single), lb
K = Theoretical lead of cam, in. per revolution
L_{max} = Total actuator stroke, in.
P = Hydraulic differential pressure at actuator, psi
Q = Hydraulic displacement per degree of oscillation, cu in. per degree
R = Radius of generating circle (evolute), or half-distance between pistons, in.
r = Cam follower roller radius, in.
r_1 = Radius of rocker arm at pivot, in.
T = Torque about cam pivot, in.-lb
t = Thickness of cylinder wall, in.
θ = Maximum angular motion (±) from midposition, degrees

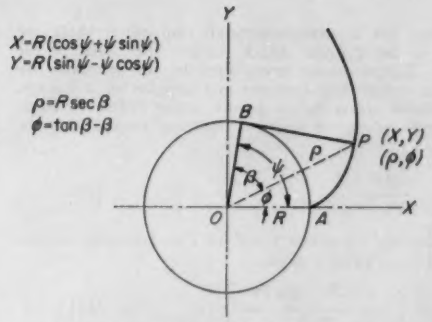


Fig. 1—Initial portion of involute curve for right circular cylinder. Equations for any point on involute curve are given for both rectangular and polar coordinate systems.

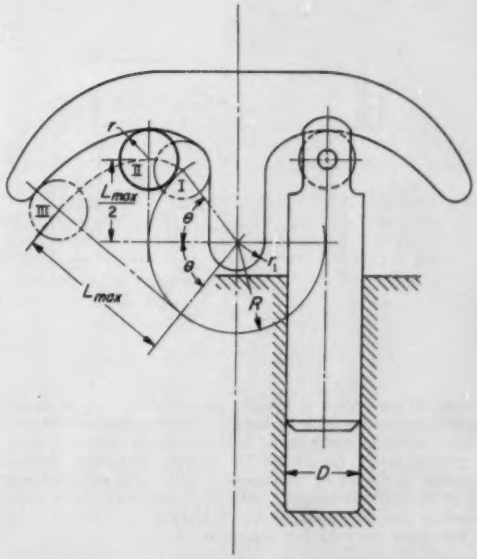
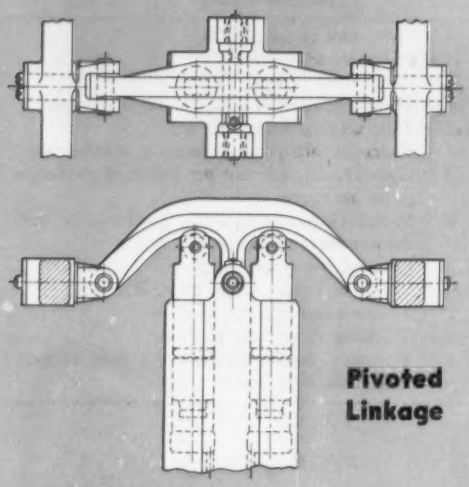


Fig. 2—Partial diagram of actuator with rocker arm centered. Circles I, II, and III show cam follower position on involute in the retracted, middle, and extended positions, respectively.



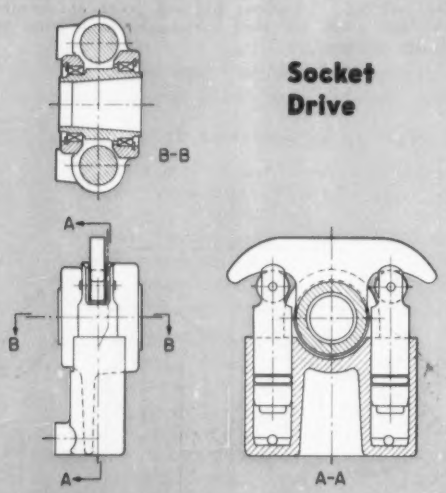
Bearings for a straight-through cam pivot shaft are located in the cylinder block outside the plane of the involute. Torque is not transmitted by the camshaft. Instead, the rocker arm becomes one member of a linkage.

Acceptable stress values permit roller radius to equal cam pivot radius, or $r = r_1$. Equation 11 can then be simplified to

$$r_1 = \frac{T \cos \theta}{2Pa} \tag{14}$$

Substituting Equations 3 and 14 into Equation 13, and using $\pi D^2_{max}/4$ for a, gives

$$D_{max} = \left[\frac{4T(2 - \cos \theta)}{\pi P} \right]^{1/3} \tag{15}$$



Size of the socket is usually governed by one or more system conditions such as torque, bending moment of the driven shaft, or some other outside consideration. Using r_1 as the outer radius of the socket, maximum piston diameter is found by multiplying both sides of Equation 11 by r_1 and rearranging, and by substituting this relationship and Equation 3 into Equation 13. Value of a is the same as used for Equation 15.

$$D_{max} = 2\left[\frac{T}{P\pi} \left(1 - \frac{r_1 \cos \theta}{r + r_1} \right) \right]^{1/3} \tag{16}$$

An involute parallel to the cam surface can be drawn through the centers of roller circles I, II, and III. Then, length $L_{max}/2$ equals the evolute arc length of angle θ according to the definition of an involute curve. Therefore,

$$\frac{L_{max}}{2} = 2\pi R \left(\frac{\theta}{360} \right) = \frac{\pi T \theta}{180 Pa} \tag{4}$$

$$L_{max} = \frac{\pi T \theta}{90 Pa} \tag{5}$$

Since hydraulic displacement is a times $L_{max}/2$, Q by definition becomes

$$Q = \frac{\frac{a L_{max}}{2}}{\theta} \tag{6}$$

Substituting Equation 5 into Equation 6,

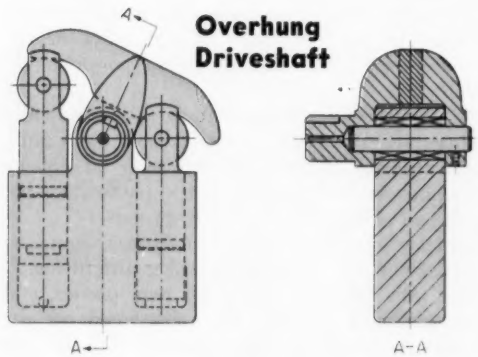
$$Q = \frac{\pi T}{180 P} \tag{7}$$

Theoretical cam lead, or advance per revolution, is

$$K = 2\pi R = \frac{2\pi T}{Pa} \tag{8}$$

Piston stroke per degree of angular motion is

$$\frac{L_{max}}{2\theta} = \frac{\pi T}{180 Pa} \tag{9}$$



Rocker-arm pivot has a straight-through shaft with a male shaft extension as the driving member.

The restricting feature is the size of the bearing housing which is usually a function of twice the piston force and therefore often bears a definite relationship to the size of the roller. Letting r_1 in this case represent the radius of the bearing housing,

$$r_1 = C r \tag{17}$$

where C is a constant. By derivation similar to that used for Equation 16, maximum piston diameter is

$$D_{max} = 2\left[\frac{T}{P\pi} \left(1 - \frac{C(r) \cos \theta}{r + Cr} \right) \right]^{1/3} \tag{18}$$

Depending on the particular bearing selected, constant C is usually chosen to be 1.25 to 1.50. Frequently, it will be found that actual maximum piston diameter will be the same for all values of C in this range.

and is useful when determining what effect a standard manufacturing tolerance for piston assembly length and cylinder depth has on angular motion error. Depending on class of work available and precision desired, choice of a system with a large value is usually safer. Also, it is interesting to note that, while stroke per degree is a function of piston area, hydraulic displacement per degree is a constant for any set of values for pressure and torque.

Next relationship is obtained with the roller in the fully retracted position shown by circle I. Cross section of the rocker arm from pivot to start of involutes is uniform and has a width of 2 r_1. In the triangle formed by the center of the pivot, the center of the roller, and a perpendicular from the center of the roller to the vertical centerline,

$$\cos\theta = \frac{r + r_1}{R} \tag{10}$$

Rearranging and substituting Equation 3 for R,

$$r + r_1 = R\cos\theta = \frac{T\cos\theta}{Pa} \tag{11}$$

Because piston diameter is limited by the type of actuator shown, limitations are expressed as

$$R \geqq r_1 + \frac{D}{2} \tag{12}$$

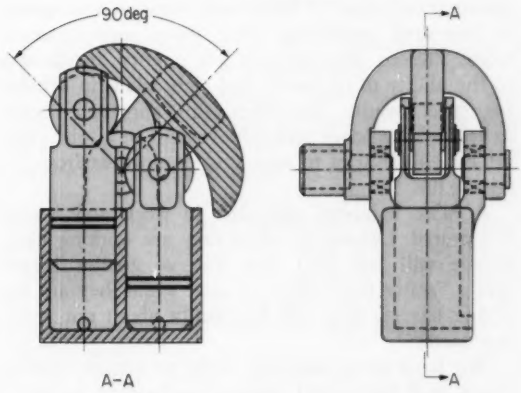
$$D_{max} = 2(R - r_1) \tag{13}$$

For other actuator types, similar relationships for R and r_1 can be written, so that D_{max} is expressed entirely in terms of known values.

Actuator Types: Five basic actuator types are shown and analyzed in the accompanying illustrations. These designs only begin to indicate the possibilities of this actuator principle, but they do illustrate fundamental design procedures. For all types presented, pistons are stepless, single-acting, nontelescoping, and arranged with parallel axes. Rollers are clevis-mounted and follow cam faces of the simplest type.

New limits of actuator performance, for instance, could result from modifying the cam surface. Side-by-side tracks spaced an unequal distance apart, and with appropriate dual rollers on each piston, could allow overlapping cam surfaces across the rocker-arm centerline of symmetry, and straddling of cylinders. In the design for maximum deflection, piston diameters can be doubled by using nonparallel piston axes.

Design for Maximum Torque

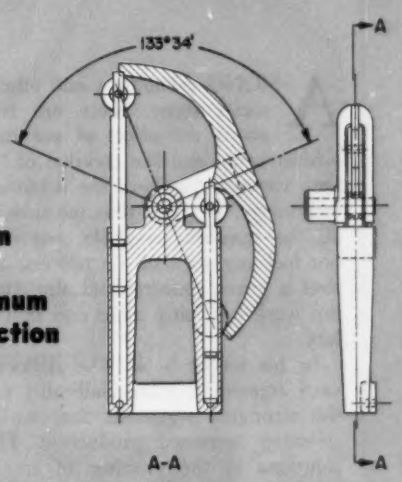


Clevis-type rocker arm accommodates large pistons and rollers and features a male drive. Involute profiles intersect at the cam centerline.

Piston and roller diameters may nearly equal the radius of the evolute as long as sufficient clearance permits the rollers to pass each other. Cylinder block material and hydraulic pressure determine the thickness of the wall separating the pistons. Maximum roller radius is determined at the position with the piston fully retracted:

$$r_{max} = \frac{T\cot\theta}{Pa} \tag{19}$$

Design for Maximum Deflection



A variation of the actuator giving maximum torque, this type can use small pistons with a straight-through camshaft. Long cam profiles permit maximum piston extension.

In this limiting case for maximum angular motion, the maximum extension of either piston occurs when the opposite tip of the rocker arm touches the cylinder block. If $x = R$ in the equation for an involute, Fig. 1, then

$$2\theta = \psi = \frac{1 - \cos\psi}{\sin\psi} \tag{20}$$

$$\psi = 133° 34' \text{ approximately}$$

Maximum permissible roller size is

$$r_{max} = R\cot\theta \tag{21}$$

$$r_{max} = 0.4289\,R$$

Maximum roller size yields the maximum space for cylinder plus cylinder wall,

$$\left(\frac{D}{2} + t\right)_{max} = 2R\cos^2\theta \tag{22}$$

$$\left(\frac{D}{2} + t\right)_{max} = 0.3108\,R$$

The Personal Side of Engineering

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To Work or Not To Work

AMONG economists and other observers of the social scene, there are two strong stands about the effect of our modern production achievements and the creation of "the new leisure." One viewpoint stresses the achievements of modern technology. It urges that we take full advantage of all the comforts available, not work so hard, and not feel any guilt in the process. The other emphasizes a grave concern that the American people do not work hard any more and that we are becoming lazy.

In his recent book, *The Affluent Society*,* Harvard economist John Galbraith sets forth perhaps the strongest argument that we have been overstressing increased production. His book includes solutions to the problem of creating jobs and of solving social imbalance without ever-greater production. He suggests, for instance, that we might abandon our puritanic ideas concerning work and give up our tendency to frown so much on idleness. We might aim for a chance to loaf a little on the job, rather than for more and more possessions. According to him, "why should men struggle to maximize income when the price is many dull and dark hours of labor?"

The opposite point of view—one commonly expressed by business executives—decries "the new leisure" as a detriment to the good, solid attitudes of hard work and productivity characteristic of this country prior to World War II. Such a view is expressed by Mr. Charles H. Brower, president of Batten, Barton, Durstine and Osborn, in an article in *Time*.† According to Mr. Brower, "work can be fun . . . the only real reward that life offers is the thrill of achievement. A piece of furniture built in your basement workshop will never be as thrilling as a sales plan that works." This reasoning is often found among managers who are perplexed and bewildered—to say nothing of irritated and angry—about their problems of motivating employees to work harder.

Which of these views will prevail is dificult to say. Probably a balanced outlook which lies somewhere in-between is the most likely. From the standpoint of psychological well-being, as well as economic health, the problem is to achieve greater enjoyment from life while adhering to high standards of work and morality.

The technological approach has continually emphasized reduction of labor costs through attainment of increased production with fewer man-hours of work. Present achievements are mighty attestations to the ability of engineers and technicians in achieving great results. But often, this approach results in lack of challenge and achievement in a job. Then an individual tries to seek greater rewards from his leisure life.

A more balanced approach to work and leisure is required. Otherwise, when they are working hard, people will feel that they deserve greater leisure and a "softer work life." Or else, while they are enjoying leisure, they will feel guilty about not working harder.

We have done relatively little to explore, understand, and implement ways of motivating people to be more efficient in their use of the techniques and methods developed by modern engineering know-how. For the most part, engineers have not been asked or have not been interested in concerning themselves with these problems. But, as people who influence the work habits and patterns of others, they are deeply involved in this dilemma. Perhaps, in the future, the engineer's direct responsibilities will include designing machines that have built-in job-interest and achievement factors.

*John K. Galbraith—*The Affluent Society*, Houghton Mifflin Co., Boston, 1958.

†June 2, 1958, p. 80.

Problem:

Design gears to run at nonstandard center distance—to be produced by cutting tools used for standard gears.

Answer:

Here's a "plug-in" calculation worksheet that simplifies the design of . . .

NONSTANDARD GEARS

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DISTANCE between gear centers is often a specification or requirement which must be met in gear design. If the ratio of a gear pair is given, it may not be possible to find gears with a standard diametral pitch that will operate successfully at the required center distance.

Gears with modified tooth proportions can be designed to operate at nonstandard center distances. Furthermore, these nonstandard gears can be so designed that they can be produced with standard cutters. However, conventional procedures for designing nonstandard gears for such applications are complicated.

To simplify design calculations for these conditions, a worksheet method is presented in this article.

The worksheet and the design method incorporated therein offer some other advantages. An existing design can be altered quickly to increase fatigue strength in bending. In addition, a variety of new experimental designs can be produced without requiring new tooling.

Range of Application: Use of either or both of two types of standard cutters is provided for on the worksheet. Although hobbing is most suitable for this type of design, interference factors occasionally prohibit its use. Therefore four possible cases are illustrated: 1. Both gears hobbed. 2. Both gears shaped by a pinion type cutter. 3. Pinion hobbed and gear shaped. 4. Gear hobbed and pinion shaped.

For this discussion, a standard cutter is defined as one which will cut a tooth thickness of one-half circular pitch when fed into a standard blank to normal depth. For the standard blank, the blank diameter exceeds the nominal pitch diameter by twice the reciprocal of the nominal, normal diametral pitch. Normal depth is the nominal depth $(d + f)$ to which the cutter cuts into the blank, if the cutter is a hob. For a pinion type shaper, normal depth is the depth required to obtain nominal tooth thickness (one half circular pitch) when the shaper is fed into a standard blank. This depth may vary appreciably from the $(d + f)$ value, depending on the sharpening history of the cutter and the number of teeth it is required to cut.

A hob has only one pressure angle, and on a standard hob the angle coincides with the normal pressure angle of the gear it cuts. A pinion type shaper

may operate at various pressure angles with the gear it cuts, but a standard cutter has a nominal pressure angle which coincides with that of the gear it cuts. Nominal means a designated or named value, and is completely independent of generating or operating conditions. Therefore, it is a convenient reference.

Cutting a pair of gears with a standard combined blank-diameter for operation on standard centers produces a tooth thickness which results in zero backlash with the mating gear if the cutter has normal depth in the blank. To incorporate the desired backlash in the gears, it is necessary to go somewhat deeper into one or both blanks.

To approximate these conditions when cutting into blanks with a nonstandard combined diameter for operation on a nonstandard center distance, a total proportional tooth-thickness change required for zero backlash is calculated first. This total proportional change is distributed to pinion and gear by means of a constant k_1 (see Nomenclature). Then the blanks are so proportioned that the tooth thickness required for zero backlash is achieved at approximately the $(d + f)$ depth. This qualification is necessary because an adjustment in both depth of cut and blank diameter must be made to maintain normal clearance. Backlash is incorporated by going somewhat deeper into one or both blanks, depending on the selection of a constant, k_2.

Using the Calculation Worksheet: Raw data, supplied by the designer, are entered in the areas boxed off for easy identification. Once the raw data have been filled in, the calculations can be performed by persons with little or no gear experience. The equations are programmed for use with a desk calculator.

The procedure for using the worksheet is to perform the operations indicated, in the order indicated, by progressing from known to unknown values. Numerical values required are found in the preceding area.

Symbols and equations in the form are best understood if they are read in word or phrase form. The symbols themselves take the form of nouns and the subscripts are modifiers. In the form, all linear values are in inches and all angular values are in radians unless noted. The form has two distinct sections. The first is concerned with values which do not change with operating conditions and the second with those that do. Since the first section explains itself, only the second section, starting with subhead 9, will be discussed. Values furnished by the designer are inserted in the boxed-off sections. Under subhead 9, the symbols in the boxes are the chosen parameters, and the designer has five from which to select. All possible choices are represented under subheadings 9A and 9B. In a completely new design, any one of the four sets of calculations under 9A may be used. For the first case under 9B, three parameters are chosen at once. After the parameters are chosen, the remaining symbols become variables. Under section 9B, group I may be chosen, but the group II must be used.

ALTERING A DESIGN: If one tooth is dropped from an existing combination which operates at a standard center distance, three parameters are immediately assigned for the changed design which results. The number of combined teeth in the original combination becomes the number of hypothetical teeth in the new combination. The original center distance remains unchanged, but is no longer standard for the new combination. It is now one tooth oversize, and therefore, the center distance index has an assigned value of 1.

Designs are often changed in this way to strengthen the pinion without making an objectionable change in the gear ratio, especially if this ratio is fairly large originally. By this device, the high-torque gear mesh in a transmission can be strengthened without expense for new tooling or for redesign of the housing.

When an accidental alteration in center distance occurs on a gear combination which is designed to run at standard center distance, a parameter for a changed design is assigned by circumstance. For example, suppose the center distance between the two gears in the sample calculation were increased to such an extent that the resulting backlash could not be tolerated. Then the original standard center-distance (4.2035) would be changed (4.2567). The worksheet is used to set specifications for a new set of gears, stronger than the first, which would operate at the new center distance with desired backlash.

ACCURACY OF DESIGN: Checks are provided in the worksheet to guard against: 1. Contact too close to the base circle of the mating gear that would cause excessive sliding, high-surface compressive-stress, and a tendency toward scoring. 2. A pointed tooth. 3. Inadequate contact ratio. The gears in the numerical example pass all the check points successfully.

If the measured thickness values of the pinion-type shaper cutters are compared with the nominal value, it is seen that the shaper for the pinion has teeth which are undersize by 0.015 in. in the normal plane, and the shaper for the gear has teeth which are oversize by 0.015 in. in the normal plane. The outside diameter measurements correspond; they are oversize for the oversize teeth and undersize for the undersize teeth.

VARIATIONS IN DESIGN: A variation in blank diameters for shaped gears and shaped-hobbed combinations can result, depending on the sharpening history of the shaper cutters. Also, the designer must know how to select the shaper cutters with the right number of teeth to avoid fillet interference in the gears being cut. Therefore, hobbing is recommended for this type of design whenever possible.

The example shows that this method results in a pinion and a gear with long and short addendum, respectively. The working depth is stubbed slightly as compared to long and short-addendum gears produced by the same cutters for standard center-distance. The pinion tooth in both cases is thickened

Nomenclature

A = Start of active profile; the distance along the line of action from its point of tangency with a base circle to its intersection with a circle whose diameter is D_l, in.
a = Operating addendum, in.
B = Backlash in the plane of rotation at the operating pitch point, in.
C = Center distance, in.
D = Diameter, in.
d = Nominal working depth, in.
F = Face width, in.
f = Nominal clearance, in.
h = Depth of tooth, in.
I = Index
k = Constant
L = Lead, in.
m = Ratio
N = Number of teeth
P = Diametral pitch, in.
p = Circular pitch, in.
S = Space thickness, in.
T = Tooth thickness, in.
t = Machining tolerance, in.
Δ = Change = Actual change when followed by a symbol, e.g., (ΔC)
= Proportional change when followed by a subscript, e.g., Δ_C
θ = Polar angle, rad (= involute function of ϕ)
σ = Semispace-thickness angle, rad
τ = Semitooth-thickness angle, rad
ϕ = Pressure angle, deg
ψ = Helix angle, deg

Subscripts:

a = Operating addendum
b = Base circle
C = Center distance
c = Combined value for a gear mesh
e = Existing gear design
F = Face contact
g = Gear
H = Hob
h = Hypothetical value
hk = Working depth
k = Working value
l = Lowest point of contact on an involute profile
M = Maximum value
m = Minimum value
n = Value in the normal plane of the gear
O = Outside of a gear (the blank)
o = Operating
P = Profile contact
p = Pinion (the gear in a combination with the fewer number of teeth)
R = Reference value
S = Shaper cutter (pinion type)
s = Standard or nominal value
T = Tooth thickness
t = Total value
x = Value in the axial plane of the gear
z = Value required for zero backlash
1,2 = Numbers used to identify different constants

Subscripts to symbols act as modifiers to the symbols. For example: $C_{s,S-g}$ means standard (s) center distance (C) for shaper cutter (S) and gear (g) mesh.

above the nominal value, but for operation on standard center distances, the gear tooth has to be thinned below the nominal value by an equal amount to obtain zero backlash. For operation on oversize center distances, tooth thickening is required for zero backlash. This thickening may be distributed to gear and pinion in any proportion desired by proper choice of the constant, k_1. Limits for this constant on the worksheet are set up so that neither tooth can be thinned below a nominal value of one-half circular pitch.

Sometimes, the designer may wish to thin the gear tooth below nominal thickness. At the same time, the pinion tooth would be thickened in excess of the combined tooth-thickness change required for zero backlash. This modification might be desirable to balance fatigue strength in bending for a pair of gears which operate at a center distance that is only slightly oversize. The only change needed on the worksheet for such a thinning-thickening of gear-pinion teeth is the replacement of 1 as the upper limit of k_1. For example, a thinning-thickening change that amounts to 10 per cent of the combined tooth-thickness change required for zero backlash would have an upper limit $k_1 = 1.1$. Hence, the only change needed on the worksheet would be the replacement of 1 as the upper limit of k_1 by 1.1.

Definitions: The following definitions are helpful in understanding the meaning of values for use in the form.

INDEX: A zero index means "on size," a plus index means oversize, and a minus index means undersize. An index is used with reference to center distance and blank size. Being independent of pitch, it is useful for direct comparison of designs of differing pitches, as well as for displaying prominent points of a single design. It is a dimensionless number, but when used with reference to center distance and blank size, may be interpreted as number of teeth. A center distance with an index of 0.5 may be said to be one-half tooth oversize. That is, it can accommodate as a standard center distance one-half tooth more than the number of combined teeth used in the combination. Similarly, a blank index of 0.5 means that the blank can accommodate as a standard size one-half tooth more than the number cut on it; hence, it is said to be one-half tooth oversize.

OPERATING RATIO: The ratio of actual to standard center distance, C/C_s.

PROPORTIONAL CHANGE: The actual change divided by the datum value from which the change is measured, e.g., $\Delta_C = \Delta C/C_s$. Then $C = (1 + \Delta_C)C_s$.

HYPOTHETICAL NUMBER OF COMBINED TEETH: The number of combined teeth in a gear mesh, which if used, would make the center distance standard. This number need not be an integer. A pair of gear sectors, each with a noninteger number of teeth in its full pitch circle, can be designed to work at standard center distance.

Design Worksheet for

This worksheet may be used for spur and helical gears. Design of helical gears is demonstrated in the numerical example because they represent a more general case. Design of spur gears is simpler because the transverse and normal planes coincide. Calculations are made by moving from one step to the next through the worksheet. Given or specified values are entered in the boxed-off areas.

1. Number of Teeth and Machining Tolerance on Gear Blanks

$N_p = 19$ $N_g = 60$ $t = +.000$ to $-.003$

$N_c = N_g + N_p = 79$

2. Nominal Diametral Pitch, Helix Angle, Pressure Angle, and Polar Angle

$P_{ns} = 10$ $\psi_s = 20°$ $\phi_{ns} = 20°$

$\cos \psi_s = 0.93969$ $\tan \phi_s = \tan \phi_{ns}/\cos \psi_s$

$\tan \psi_s = 0.36397$ $= 0.38733$

$\csc \psi_s = 2.9238$ $\phi_s = 21°1729$

$\tan \phi_{ns} = 0.36397$ $\cos \phi_s = 0.93249$

$P_s = P_{ns} \cos \psi_s$ $\sec \phi_s = 1.0724$

$= 9.3969$ $\theta_s = 0.017794$

3. Cutter ($d + f$), Number of Teeth, Measured Outside Diameter, and Measured Thickness on Shaper Cutter After Last Sharpening Prior to Use

$(d+f)_H = 2.25/P_{ns} = 0.225$ $N_{Sp} = 28$

$(d+f)_S = 2.25/P_{ns} = 0.225$ $N_{Sg} = 38$

$D_{OS,p} = 3.1885$ $T_{nS,p} = 0.1421$

$D_{OS,g} = 4.3351$ $T_{nS,g} = 0.1721$

$N_{c,S-p} = N_{Sp} + N_p = 47$

$N_{c,S-g} = N_{Sg} + N_g = 98$

4. Nominal Pitch Diameter and Center Distance

$D_s = (1/P_s)N$ $C_s = [0.5(1/P_s)]N_c$

$D_{sp} = 2.0219$

$D_{sS,p} = 2.9797$ $C_{s,p-g} = 4.2035$

$D_{sg} = 6.3851$ $C_{s,S-p} = 2.5008$

$D_{sS,g} = 4.0439$ $C_{s,S-g} = 5.2145$

5. Base Circle Diameter and Base Circular Pitch

$D_b = (\cos \phi_s/P_s)N$ $D_{bg} = 5.9540$

$D_{bp} = 1.8854$ $D_{bS,p} = 2.7785$

$P_b = (\cos \phi_s/P_s)\pi = 0.31175$ $D_{bS,g} = 3.7709$

6. Face Width, Nominal Normal Circular-Pitch, Axial Pitch, Face Contact Ratio and Lead

When calculating m_F, use the smaller of the two face widths for F_m (in this case 1.20).

$F_p = 1.25$ $F_g = 1.20$ $L = p_x N$

$p_{ns} = \pi/P_{ns} = 0.31416$ $L_p = 17.4522$

$p_x = (\pi/P_{ns})\csc \psi_s = 0.91854$ $L_g = 55.1123$

$m_F = F_m/p_x = 1.306$ $L_{Sp} = 25.7191$

$L_{Sg} = 34.9045$

7. Nominal Thickness

$T_{nz,sc} = \pi/P_{ns} = 0.3142$

$T_{nz,s} = T_{nS,s} = 0.5(\pi/P_{ns}) = 0.1571$

8. Nominal Blank Diameter

$D_{Os,c} = (N_c/P_s) + (4/P_{ns}) = 8.8070$

$D_{Os} = (N/P_s) + (2/P_{ns})$

$D_{Os,p} = 2.2219$

$D_{Os,g} = 6.5851$

$D_{Os,S} = (N_S/P_s) + (2.5/P_{ns})$

$D_{Os,Sp} = 3.2297$

$D_{Os,Sg} = 4.2939$

9. Parameters Chosen to Determine Operating Conditions

Under A, the four subheadings illustrate alternate selections of the design parameters I_C, Δ_C, m_o, N_{ch}, and C, and the calculation of values for the four remaining terms. The particular selection depends upon whether the designer chooses to think in terms of the choice of a value for the center-distance index, proportional center-distance change, operating ratio, or hypothetical number of combined teeth as the basis for starting a new design.

Under B, heading I gives a common cut-and-try method on an analytical design basis, which eliminates the guess work. Parameters boxed off in this section are selected by the designer. When the center distance is altered by accident, Part II, the boxed-off value is the new measured center distance.

A. Completely New Design (Choose one calculation group).

$I_C = 2(\Delta C)P_s = 1$

$N_{ch} = 2CP_s = N_c + I_C = 80$

$m_o = C/C_s = N_{ch}/N_c = 1.01266$

$\Delta_C = m_o - 1 = 0.01266$

$C = 0.5\, N_{ch}/P_s = 4.2567$

$\Delta_C = 0.01266$

$m_o = 1 + \Delta_C = 1.01266$ $N_{ch} = m_o N_c = 80$

$I_C = N_{ch} - N_c = 1$ $C = 0.5\, N_{ch}/P_s = 4.2567$

$m_o = 1.01266$

$\Delta_C = m_o - 1 = 0.01266$ $N_{ch} = m_o N_c = 80$

$I_C = N_{ch} - N_c = 1$ $C = 0.5\, N_{ch}/P_s = 4.2567$

$N_{ch} = 80$

$I_C = N_{ch} - N_c = 1$ $m_o = N_{ch}/N_c = 1.01266$

$\Delta_C = m_o - 1 = 0.01266$ $C = 0.5\, N_{ch}/P_s = 4.2567$

B. New Design Resulting from Alteration of an Existing Design in which $C = C_s$

I. By Reducing N_c by 1, Leaving C Unchanged

$N_{ch} = N_{cs} = 80$ $C = C_{sc} = 4.2567$ $I_C = 1$

$m_o = N_{ch}/N_c = 1.01266$ $\Delta_C = m_o - 1 = 0.01266$

II. By Accidental Alteration Of C

$C = 4.2567$

$N_{ch} = 2CP_s = 80$ $I_C = N_{ch} - N_c = 1$

$m_o = N_{ch}/N_c = 1.01266$ $\Delta_C = m_o - 1 = .01266$

10. Backlash, Operating Pressure Angle, Polar Angle, Helix Angle, and Diametral Pitch

$B = 0.004$ to 0.007

$\sec \phi = m_o \sec \phi_s = 1.0860$ $\tan \psi = m_o \tan \psi_s = .36858$

$\phi = 22.^\circ 9552$ $\psi = 20.^\circ 2329$

$\sin \phi = 0.39001$ $\cos \psi = 0.93829$

$\theta = 0.022908$ $P_n = P/\cos \psi = 9.8897$

$P = P_s/m_o = 9.2794$

11. Constant for Distributing to Pinion and Gear the Total Tooth Thickness Change from Nominal Circular Pitch Required for Zero Backlash

$0 \le k_1 \le 1$ (Designer's choice within prescribed limits)

$k_1 = 1$

12. Proportional Tooth Thickness Change

$\Delta_{Tc} = (\theta - \theta_s)N_c/\pi = 0.12860$

$\Delta_{Tp} = 2k_1 \Delta_{Tc} = 0.25720$

$\Delta_{Tg} = (2 - 2k_1)\Delta_{Tc} = 0$

13. Tooth Thickness Required for Zero Backlash

$T_{nz,c} = (\pi/P_{ns})(1 + \Delta_{Tc}) = 0.3546$

$T_{nz} = (0.5\pi/P_{ns})(1 + \Delta_T)$

$T_{nz,p} = 0.1975$ $T_{nz,g} = 0.1571$

14. Constant for Distributing to Pinion and Gear the Total Tooth Thickness Change $(\Delta T)_{nc}$ from $T_{nz,c}$ Required for Backlash

$0 \le k_2 \le 1$ (Designer's choice within prescribed limits)

$k_2 = 0.5$

$(\Delta T)_{nc} = -(\cos \psi_s/m_o)B = (-.00371)$ to $(-.00650)$

15. Blueprint Tooth Thickness Specification

$T_{np} = T_{nz,p} + k_2(\Delta T)_{nc} = .1956 - .1943$

$T_{ng} = T_{nz,g} + (1 - k_2)(\Delta T)_{nc} = .1552 - .1539$

16. Semithickness Angle Measured on the Base Circle

$\tau_{bm} = (T_{nm}P_{ns}/N) + \theta_s$

$\tau_{bm,p} = 0.12006$ $\tau_{bm,g} = 0.043444$

$\tau_{bz} = (T_{nz}P_{ns}/N) + \theta_s$

$\tau_{bz,p} = 0.12174$ $\tau_{bz,g} = 0.043977$

$\sigma_{bS} = [(\pi - T_{nS}P_{ns})/N_s] - \theta_s$

$\sigma_{bS,p} = 0.043655$ $\sigma_{bS,g} = 0.019590$

17. Blank Index for $(d + f)$ Depth of Cut into Blank by Cutter

A. Both Gears Hobbed

$I_{oc} = \pi \Delta_{Tc}/\tan \phi_s = 1.0431$

$I_{op} = k_1 I_{oc} = 1.0431$ $I_{og} = (1 - k_1)I_{oc} = 0$

B. Both Gears Shaped

Reference Operating Values for Mesh between Shaper and Pinion

$C_R = 0.5(D_{OS,p} + D_{Os,p}) - (d + f)_S = 2.4802$

$m_o = C_R/C_{s,S-p} = 0.99176$ $\theta_R = 0.014707$

$\sec \phi_R = m_o \sec \phi_s = 1.0636$

$\tan \psi_R = m_o \tan \psi_s = 0.36097$

$\sec \psi_R = 1.0632$

$P_{nR} = P_s \sec \psi_R/m_o = 10.074$

$S_{nR,Sp} = (\sigma_{bs,p} + \theta_R)N_{Sp}/P_{nR} = 0.1622$

$T_{nR,p} = (\tau_{bz,p} - \theta_R)N_p/P_{nR} = 0.2019$

Actual Operating Values for Mesh between Shaper and Pinion

$\theta = [(T_{nR,p} - S_{nR,Sp})P_{nR}/N_{c,S-p}] + \theta_R = .023216$

$\sec \phi = 1.0868$

$I_{op} = [(\sec \phi/\sec \phi_R) - 1]N_{c,S-p} = 1.0252$

Reference Operating Values for Mesh between Shaper and Gear

$C_R = 0.5(D_{OS,g} + D_{Os,g}) - (d + f)_S = 5.2351$

$m_o = C_R/C_{s,S-g} = 1.0040$ $\theta_R = 0.019370$

$\sec \phi_R = m_o \sec \phi_s = 1.0767$

$\tan \psi_R = m_o \tan \psi_s = 0.36543$

$\sec \psi_R = 1.0647$

$P_{nR} = P_s \sec \psi_R/m_o = 9.9650$

$S_{nR,Sg} = (\sigma_{bS,g} + \theta_R)N_{Sg}/P_{nR} = 0.1486$

$T_{nR,g} = (\tau_{bz,g} - \theta_R)N_g/P_{nR} = 0.1482$

Actual Operating Values for Mesh between Shaper and Gear

$\theta = [(T_{nR,g} - S_{nR,Sg})P_{nR}/N_{c,S-g}] + \theta_R = .019330$

$\sec \phi = 1.0766$

$I_{og} = [(\sec \phi/\sec \phi_R) - 1]N_{c,S-g} = -0.0091$

$I_{oc} = I_{op} + I_{og} = 1.0161$

C. Pinion Hobbed, Gear Shaped

$I_{op} = 1.0431$ From A $I_{og} = 0.0091$ From B

$I_{oc} = I_{op} + I_{og} = 1.0340$

D. Gear Hobbed, Pinion Shaped

$I_{op} = 1.0252$ From B $I_{og} = 0$ From A

$I_{oc} = I_{op} + I_{og} = 1.0252$

18. Total Depth of Cut into Blank to Maintain Normal Clearance

The combined effect of altering the total depth from the $(d + f)$ value by the addition of the term enclosed in brackets in the equation for h_t, and changing the blank index value from I_o by the addition of the term enclosed in brackets in the equation for D_o, is to leave tooth thicknesses and root diameters unaffected while restoring the normal clearance of $0.25/P_{ns}$.

$h_t = \{[0.25(I_c - I_{oc})]/P_S\} + (d + f)$

$h_t = 0.2239$ for 17A

$h_t = 0.2246$ for 17B

$h_{t,p} = 0.2241$ for 17C

$h_{t,g} = 0.2241$ for 17C

$h_{t,p} = 0.2243$ for 17D

$h_{t,g} = 0.2243$ for 17D

19. Blueprint Blank Diameter Specification

$D_O = \{[0.5(I_c - I_{oc})] + I_o + N\}/P_S + 2/P_{ns} + t$

$D_{Op} = 2.331$ to 2.328 } for 17A
$D_{Og} = 6.583$ to 6.580 }

$D_{Op} = 2.330$ to 2.327 } for 17B
$D_{Og} = 6.583$ to 6.580 }

$D_{Op} = 2.331$ to 2.328 } for 17C
$D_{Og} = 6.582$ to 6.579 }

$D_{Op} = 2.330$ to 2.327 } for 17D
$D_{Og} = 6.584$ to 6.581 }

20. Check to Eliminate Dangerous Contacts Too Close to the Base Circle of the Mating Gear:

$$D_O \leq [D_b^2 + (2\,C \sin \phi)^2]^{1/2} - 0.012$$

For 17A	For 17B	For 17C	For 17D
✓	✓	✓	✓

21. Functions of Helix Angle and Pressure Angle at Blank Diameter, and Minimum Tooth Thickness (Land) at Blank Diameter

$\tan \psi_O = (\pi/L) D_{OM}$

$\tan \psi_{Op} = 0.41961$ $\tan \psi_{Og} = 0.37525$ } for 17A
$\sec \psi_{Op} = 1.0845$ $\sec \psi_{Og} = 1.0681$ }

$\tan \psi_{Op} = 0.41943$ $\tan \psi_{Og} = 0.37525$ } for 17B
$\sec \psi_{Op} = 1.0844$ $\sec \psi_{Og} = 1.0681$ }

$\tan \psi_{Op} = 0.41961$ $\tan \psi_{Og} = 0.37519$ } for 17C
$\sec \psi_{Op} = 1.0845$ $\sec \psi_{Og} = 1.0681$ }

$\tan \psi_{Op} = 0.41943$ $\tan \psi_{Og} = 0.37531$ } for 17D
$\sec \psi_{Op} = 1.0844$ $\sec \psi_{Og} = 1.0681$ }

$\sec \phi_O = (1/D_b) D_{OM}$

$\sec \phi_{Op} = 1.2363$ $\sec \phi_{Og} = 1.1056$
$\theta_{Op} = 0.098360$ $\theta_{Og} = 0.030919$ } for 17A
$\sin \phi_{Op} = 0.58799$ $\sin \phi_{Og} = 0.42650$

$\sec \phi_{Op} = 1.2358$ $\sec \phi_{Og} = 1.1056$
$\theta_{Op} = 0.098067$ $\theta_{Og} = 0.030919$ } for 17B
$\sin \phi_{Op} = 0.58754$ $\sin \phi_{Og} = 0.42650$

$\sec \phi_{Op} = 1.2363$ $\sec \phi_{Og} = 1.1055$
$\theta_{Op} = 0.098360$ $\theta_{Og} = 0.030876$ } for 17C
$\sin \phi_{Op} = 0.58799$ $\sin \phi_{Og} = 0.42633$

$\sec \phi_{Op} = 1.2358$ $\sec \phi_{Og} = 1.1058$
$\theta_{Op} = 0.098067$ $\theta_{Og} = 0.031004$ } for 17D
$\sin \phi_{Op} = 0.58754$ $\sin \phi_{Og} = 0.42685$

$T_{nO,m} = (\tau_{bm} - \theta_O) D_{OM} / \sec \psi_O$

$T_{nO,p} = 0.047$ $T_{nO,g} = 0.077$ for 17A
$= 0.047$ $= 0.077$ for 17B
$= 0.047$ $= 0.077$ for 17C
$= 0.047$ $= 0.077$ for 17D

CHECK FOR ADEQUATE LAND: $t_{nO} - (0.40/P_{ns}) \geq 0$

For 17A	For 17B	For 17C	For 17D
✓	✓	✓	✓

22. Start of Active Profile and Contact Diameter

$$A_p = [2\,C \sin \phi - (D_{Og} \sin \phi_{Og})]/2$$

$= 0.25633$ for 17A
$= 0.25633$ for 17B
$= 0.25710$ for 17C
$= 0.25497$ for 17D

$$A_g = [2\,C \sin \phi - (D_{Op} \sin \phi_{O,p})]/2$$

$= 0.97485$ for 17A
$= 0.97567$ for 17B
$= 0.97485$ for 17C
$= 0.97567$ for 17D

$D_l = [2\,A^2 + D_b^2]^{1/2}$

$D_{lp} = 1.9539$ $D_{lp} = 6.2651$ for 17A
$= 1.9539$ $= 6.2656$ for 17B
$= 1.9543$ $= 6.2651$ for 17C
$= 1.9531$ $= 6.2656$ for 17D

23. Profile Contact Ratio and Total Contact Ratio

$m_P = (C \sin \phi - A_p - A_g)/p_b$
$= 1.376$ for 17A
$= 1.373$ for 17B
$= 1.374$ for 17C
$= 1.378$ for 17D

$m_t = m_P + m_F$
$= 2.682$ for 17A
$= 2.679$ for 17B
$= 2.680$ for 17C
$= 2.684$ for 17D

CHECK FOR ADEQUATE CONTACT RATIO: $m_t \geq 1.40$

For 17A	For 17B	For 17C	For 17D
✓	✓	✓	✓

24. Proportional Change in Operating Addendum and Working Depth Constants

REFERENCE EQUATIONS

For Datum Values

$k_{aS} = 1$ $a_S = 1/P_n$

$k_{hk,S} = 2$ $h_{kS} = 2/P_n$

For Actual Values

$k_a = (1 + \Delta_{ka}) k_{aS}$ $a = k_a/P_n$

$k_{hk} = (1 + \Delta_{k,hk}) k_{hk,S}$

$h_k = k_{hk}/P_n$

$\Delta_{ka} = \{[(D_O N_c - 2NC) P_n/2N_c] - k_{aS}\}/k_{aS}$

$\Delta_{k,hk} = 0.5(\Delta_{k,ap} + \Delta_{k,ag})$

	For 17A	For 17B
$\Delta_{k,ap}$	0.402	0.402
$\Delta_{k,ag}$	−0.421	−0.425
$\Delta_{k,hk}$	−0.0095	−0.115

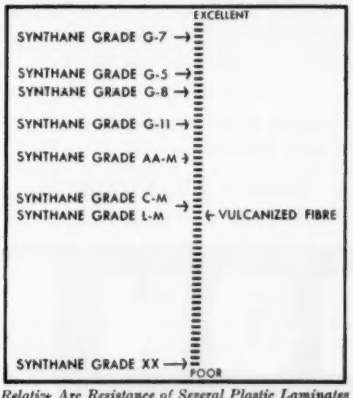
	For 17C	For 17D
$\Delta_{k,ap}$	0.397	0.397
$\Delta_{k,ag}$	−0.421	−0.415
$\Delta_{k,hk}$	−0.012	−0.009

Arc Resistance with Synthane Laminated Plastics

Resistance to arcing is important in such applications as terminal boards, switch and fuse blocks, and circuit breakers. Usually, however, arc resistance alone is not sufficient to satisfy job requirements. Ceramics, for example, are excellent for arc resistance but they break easily and are difficult to machine. Mica has excellent arc resistance yet lacks strength.

Laminates have arc resistance plus

Laminated plastics have many desirable properties in combination. All grades of plastic laminates have good electrical properties. All have good dielectric strength, dissipation factor and insulation resistance. Some laminates also have excellent arc resistance and some—the phenolic laminates, for instance—are relatively poor in this respect.



Relative Arc Resistance of Several Plastic Laminates and Vulcanized Fibre.

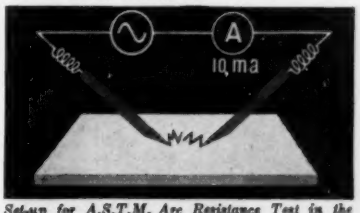
It is this failing of the phenolic grades which may have deterred you from thinking of laminates when arc resistance was required. But, outstanding progress has been made to supply laminates with excellent arc resistance. For example, Grades CM, LM, G-5 and G-7 have outstanding arc resistance properties.

There are several tests for arc resistance. One commonly used is ASTM Method D495-56T, which approximates service conditions in alternating current circuits operating at a high voltage, with currents limited to units and tens of milliamperes. Two pointed electrodes, ¼" apart (see drawing), rest upon the material to be tested. The arc is applied intermittently, and at first mildly. Later the time between flashes is decreased and the amperage is increased until the arc finally burns a conducting path between the electrodes. The total time in seconds until failure occurs is the arc resistance of the material.

Arc resistance is related to time

Since the severity of the arc is progressively increased, the comparative arc resistance of two materials is not in direct proportion to the time. The accompanying chart gives you a fairly accurate relationship of the arc resistance of Synthane laminates—using the ASTM method. The first four are glass base grades. G-7, containing a silicone resin, tops the list in arc resistance as well as in dielectric strength, dissipation factor, insulation resistance and moisture resistance.

For specific information relating to Arc Resistance for your application or for the combined properties of Synthane laminates, write Synthane Corporation, 5 River Road, Oaks, Pa.



Set-up for A.S.T.M. Arc Resistance Test in the Synthane Laboratory.

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Circle 471 on Page 19

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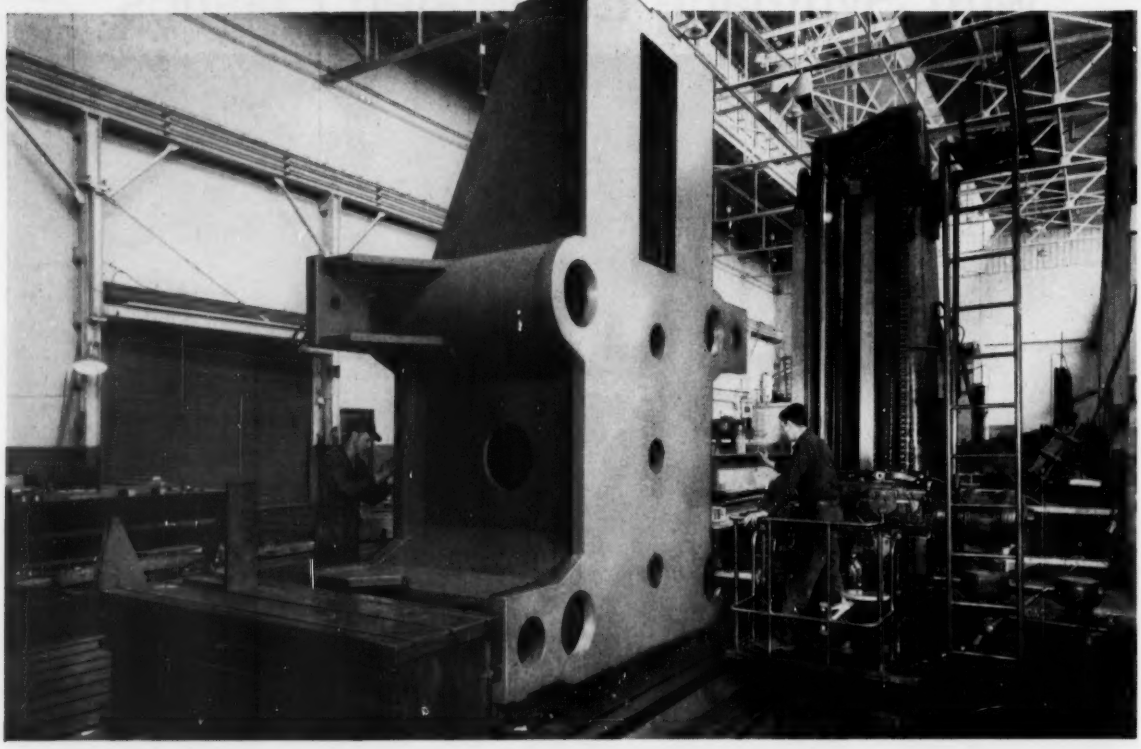

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Limit Switches versus Proximity Switches

JOHN M. MORGAN Jr.
Manager, Development Research Dept.
The Cincinnati Milling Machine Co.
Cincinnati, Ohio

THE majority of contact-making sensing elements used on machines today are limit switches. However, proximity switches, although relatively new and not completely proven, are playing an increasingly important part in many types of automatic control. When properly applied, both do an outstanding job with a high degree of reliability.

Limit Switches: Practically all limit-switch designs are based upon the operation of a load-and-fire mechanism. This principle is used to give the snap action that is very important to long contact life and accuracy. Most limit switches are provided with a normally open and normally closed contact. Some precision switches, however, have one common terminal between one side of the normally open and normally closed contacts. This lack of flexibility limits their use for many applications, particularly when the extra contacts of the switch are to be used for safety interlocking reasons.

Limit switches are simple, positive, accurate, easy to mount and wire, and low in cost. For most applications they have adequate contacts, adequate power-handling capacity, snap action, and small differential. When properly applied mechanically without excessive load on the contacts, limit switches give a high degree of reliability.

The main limitation of these switches is in certain applications where presence of dirt and contaminants cause failure. Limit switches cannot be used where it is necessary to sense parts without physical contact. They should not be used in applications such as counting where extremely fast operation is required, and where life is measured by hundreds of million of operations.

Limit switches have been used as input devices in static-control systems. In such applications, care must be taken to insure that the switch contacts are suitable for low power-level operation. Table 1 can be used as a guide when considering relative merits of these devices.

Proximity Switches: Design of these switches is based upon use of a sensing element and a control or power unit which operates the sensing device and gives corresponding output signals. Most proximity switches can use either a relay for output or can generate signals to be fed into static-control elements..

The outstanding feature of proximity switches is their ability to sense the presence of a part or operating element without actual physical contact. In general, the part to be sensed must be of a ferrous material, although some proximity

Table 1—Relative Desirability of Sensing Devices*

Attribute	Mechanical Limit Switches	Vane-Operated Limit Switches	Proximity Switches
Reliability	2	1	1
Simplicity	1	1	3
Positiveness	1	2	3
Fail-safe	1	2	3
Foolproof	1	2	3
Accuracy	1	2	3
Fast operation	3	2	1
Size-sensing unit	2	3	1
Size-total	1	2	3
Cost	1	2	3
Mounting and wiring	1	1	2
Suitable for adverse environment	3	2	1
Adequate number of contacts	1	3	2
Power handling capacity	1	3	2
Snap action	1	2	2
Small differential	1	2	3
Low operating force	2	1	1
Sensing without contacts	–	2	1
Provision for overtravel	2	1	1

*Lowest number indicates most desirable switch.

switches can also sense nonferrous objects. Although their operating range is generally from a few thousandths of an inch to 1 in., these switches can be obtained with operating ranges to a distance of several feet.

When properly applied, proximity switches are quite reliable. They can be extremely fast in operation and, feeding into static elements, are ideal for counting operations. Most of the sensing elements are made for operation in adverse environments.

In general, proximity switches are not as simple and positive and not as fail-safe as limit switches. They normally have a larger differential and do not have the snap action of a limit switch. In cost, proximity switches are 6 to 10 times more expensive than limit switches.

Some types of proximity switches require shielded leads between the sensing element and the control unit. This makes wiring somewhat more difficult, particularly when the length of lead between the sensing element and the control unit is important. Proper precautions must be taken at junction points in the shielded cable such as occur at terminal boards.

Table 2—Operating Life of Sensing Devices

Device	Life in Millions of Operations When Controlling . . . 00 Relay	Small Relay	Static Relay
Mechanical limit switch....	5+	30+	50+
Vane-operated limit switch	5+	30+	250+
Proximity switch	—	30+	500+

Vane-Operated Limit Switches: This relatively new device is neither a true limit switch nor a proximity switch. It is designed to give leverless operation with less cost and fewer mounting problems than proximity switches. It does not require a separate power supply and is designed for long operating life. Most of its characteristics fall in between those of the limit switch and proximity switch, Table 1.

The major limitation of the vane-operated limit switch is that it can be provided with only a single contact which must be specified as normally open or normally closed. The contact is designed for long life when operating a low coil-current relay but is somewhat inadequate in power-handling capacity.

Fail-Safe Features: The importance of the ability of a sensing device to fail safe varies with the application. If a limit switch or proximity switch is used in a counting or permissive application, failure to function properly is normally less detrimental than if it has been used to stop the motion of a machine slide. For maximum safety, circuits are generally arranged so that all relays and solenoids open when the stopping operation takes place.

Proximity switches normally depend upon the picking up of a relay to give the same contact opening provided by the limit switch. In some cases, reverse operation can be obtained. Since tubes can be either conducting or nonconducting after failure, it is normally not considered good practice to use any device containing electronic tubes in critical applications unless there is no practical alternative.

Operating Life: One of the most imporant features of any device is its operating life. Since the contacts are the most common limiting factor in all devices and are affected by external load, switch life is a function of contact performance. Table 2 shows the approximate life of various sensing devices with different external loads.

Paper A-5919, 23rd Annual Machine Tool Electrification Forum sponsored by the Westinghouse Electric Corp., Buffalo, April, 1959; 12 *pp.*

materials

Notch Sensitivity of Titanium Sheet Alloys

G. Sachs, J. G. Sessler, R. F. Pray, and T. H. Yeh, Syracuse University Research Institute

Basic relations which govern behavior of titanium alloys in the presence of stress concentration caused by notching. Notch tensile strengths are determined at room temperature for 4340 steel heat treated to various strength levels, and for titanium alloys 6Al-4V and 5Al-1.5Fe-1.4Cr-1.2Mo. Effects of notch geometry, specimen shape, type of loading, material history, and test temperature are included in the investigation. This information leads to recommendations pertaining to the design of notch tensile specimens for evaluating relative notch sensitivity of titanium sheet alloys.

Conclusions indicate that:

1. Cylindrical and prismatic specimens of notch ductile steels and ductile titanium alloys exhibit a nearly linear increase in notch strength ratio with increasing notch depth.
2. Notch embrittlement is observed for steels and titanium alloys if tensile strength levels exceed approximately 180,000 psi and 150,000 psi, respectively.
3. At room temperature, alloy Ti-6Al-4V (165,000 psi) reveals only mild notch embrittlement as compared to rather severe notch sensitivity exhibited by high strength 4340 steel (270,000 psi).
4. At high temperatures, the titanium alloy is practically insensitive to notches within 1000 hr at any temperature to 900 F according to stress-rupture strength data.
5. Alloy Ti-155A (220,000 psi) is extremely notch sensitive at room temperature and below. This alloy becomes less sensitive with increasing temperature and exhibits nearly ductile behavior at 800 F.
6. Relative notch sensitivity of sheet materials can best be evaluated by testing flat specimens notched at two edges with radii of 0.010 in. or less, and with a maximum thickness-to-width ratio of 0.25. A notch of 60 deg included angle and 30 to 50 per cent notch depth is recommended.

ASME paper 59-Met-2, *ASME Metals Engineering Conference, Albany, May,* 1959; 9 *pp.*

Applying Ceramic Magnets to Permanent-Magnet Motors

R. A. Scholten, The Indiana Steel Products Co.

Eight different designs of motor-field circuits showing the arrangement of a permanent-magnet material in the magnetic circuit close to the armature. Designs are shown

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1/21/59

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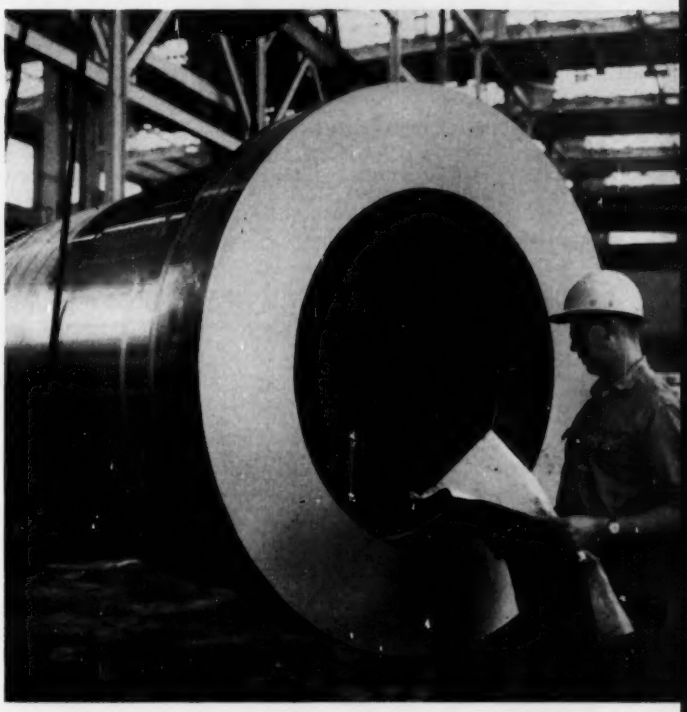

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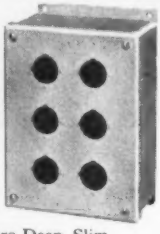

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Circle 474 on Page 19

in order of increasing flux obtained with oriented and unoriented barium ferrite materials. Other practical circuits using ceramic magnets are covered.

MPIF Paper, MPIF Fifteenth Annual Meeting, Detroit, Mich., April, 1959; 5 *pp.*

Continuous Compaction Process For Metal or Ceramic Powders

F. Emley and C. Deibel, Westinghouse Electric Corp.

Description of a new technique for pressing metal or ceramic powders into continuous bars. The process is unique in that bars of relatively large cross section and unlimited length can be readily produced. Experiments indicate that continuous compaction is an excellent and economical means for forming specialty metals and alloys compared to other fabricating methods. Present equipment, such as reciprocating type presses, can be easily modified for experimentation, development, and small-scale production of limited-length bars from powder, granular, or sponge raw materials.

MPIF Paper A-5925, *MPIF Fifteenth Annual Meeting, Detroit, Mich., April,* 1959; 15 *pp.*

A New Basis for Inspecting Sintered-Metal Parts

B. Bovarnick, Watertown Arsenal

A basic engineering investigation to establish requirements of a nondestructive test as a 100-per cent inspection method for in-process quality control and acceptance testing of sintered-metal parts. Specimens are tested by a nondestructive technique based on the principle that surface energy of a piece is dependent upon its surface character, i.e., measuring electrochemical potential. A high statistical correlation exists between the potential as a measure of the extent of sintering and the strength obtained.

MPIF Paper, MPIF Fifteenth Annual Meeting, Detroit, Mich., April, 1959; 10 *pp.*

mechanical

Design Considerations for Nuclear Gas-Turbine Engines

D. R. Riley, General Electric Co.

Effects of power-plant configurations, cycle, radiation level, residual radiation, and nuclear heating on the design of gas-turbine engines

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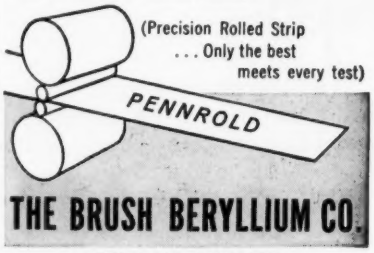

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for nuclear aircraft. The relative stability of metals, ceramics, plastics, elastomers, and semiconductors exposed to radiation with respect to changes in physical properties is covered.

ASME paper 59-GTP-13, *ASME Gas Turbine Power Conference and Exhibit, Cincinnati, March,* 1959; 7 *pp.*

Radial Thrust in Centrifugal Pumps

A. Agostinelli, D. Nobles, and C. R. Mockridge, Worthington Corp.

Report of an investigation to determine magnitude and directions of unbalanced radial forces on centrifugal-pump impellers. The paper covers single volutes for a wide specific speed range, double volutes, concentric casings, and modifications of the concentric casing. Results are presented in graphical form.

ASME paper 59-HYD-2, *ASME Hydraulic Conference, Ann Arbor, Mich., April,* 1959; 6 *pp.*

Flow Considerations in Turbine Design

W. L. Stewart, W. J. Whitney, and H. J. Schum, NASA

Significance of three-dimensional flow considerations in turbine design. Fundamental concepts and equations show how the more important factors affecting velocity distribution through turbine blading can be considered. Studies on a mixed-flow turbine point out operational problems encountered as the result of three-dimensional effects predictable by flow analysis in the radial-axial plane.

ASME paper 59-HYD-1, *ASME Hydraulic Conference, Ann Arbor, Mich., April,* 1959; 8 *pp.*

Steady Creep of a Tube under Bending and Internal Pressure

I. Finnie, Shell Development Co.

Effects of combined stress-creep on thin-walled tubing caused by a combination of bending moments and internal pressure. Bending strain rates under the combined loading may be considerably greater than that due to bending alone. Such a magnification, which does not occur with elastic stresses, may be of considerable importance in designing high-temperature piping systems. If maximum bending stress is small compared to pressure stress,

a very simple expression may be obtained for the ratio of bending creep rate with and without internal pressure.

ASME paper 59-Met-5, *ASME Metals Engineering Conference, Albany, May,* 1959; 3 *pp.*

Designing Centrifugal Impellers

J. J. Kramer and W. M. Osborn, NASA, and J. T. Hamrick, Thompson Products Inc.

Procedures for designing the hub-shroud contour and blade shape of mixed-flow and centrifugal impellers. Experimental results indicate that these design procedures are reliable.

ASME paper 59-HYD-20, *ASME Hydraulic Conference, Ann Arbor, Mich., April,* 1959; 11 *pp.*

Design Studies of a 250-hp Gas-Turbine Engine

S. H. Spooner, Fort Eustis, Va.

A summary of studies performed by engine manufacturers to determine the feasibility of developing a free-shaft gas-turbine engine of 250 hp. The studies provide a basis for establishing specifications for use in design competition for such engines.

ASME paper 59-GTP-7, *ASME Gas Turbine Power Conference and Exhibit, Cincinnati, March,* 1959; 5 *pp.*

Designing Pressurized Cylinders For High Temperature Use

J. F. Traexler, Westinghouse Electric Corp.

Derivation of general equations for stresses in a thick-walled cylinder in a state of plane strain and considering steady-state creep. A specific form of the creep-rate function is assumed, and numerical examples are included to show the effect of geometry and material properties.

ASME paper 59-Met-8, *ASME Metals Engineering Conference, Albany, May,* 1959; 5 *pp.*

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

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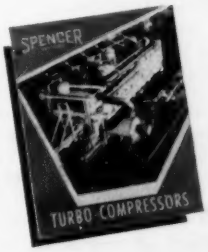

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Circle 478 on Page 19

Helpful Literature
for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—Page 19

Dust Collector

The Type D Roto-Clone dust collector is designed for collecting moderate loadings of dry granular materials. Engineering and performance data are given on six models with capacities ranging to 4940 cfm in Bulletin 272B. This packaged unit combines an exhauster, dust separator, and storage hopper. 20 pages. American Air Filter Co., 215 Central Ave., Louisville 8, Ky. G

Circle 601 on Page 19

Office Automation

"New Concepts in Practical Automation and Electronic Computers" is title of Bulletin S-463. It explains the use of the automatic Keysort system to achieve automation without transfer of data to other unit cards or tape. Also described is the LGP-30 general-purpose computer for engineering, office, and management procedures. 6 pages. Royal McBee Corp., Port Chester, N. Y. D

Circle 602 on Page 19

Fractional HP Motors

Fractional horsepower electric motors catalogued in Form 6773 include shaded pole and permanent split capacitor units, direct-current motors, blowers, and special products. Dimensional, performance, and other basic information is furnished. 12 pages. Redmond Co., Owosso, Mich. H

Circle 603 on Page 19

Indicator Lights

Datalite ultra-miniature indicator lights are used in data-processing equipment and computers. Units with both replaceable and nonreplaceable lamps are discussed in Form L-160A. Lamp data, features, and schematics are provided. 8 pages. Dialight Corp., 60 Stewart Ave., Brooklyn 37, N. Y. D

Circle 604 on Page 19

Worm Gear Jacks

Capacities of Series 1800 worm gear jacks, comprising eight models, range from 2 to 100 tons. Jacks can be used singly, in tandem, or in multiple jacking arrangements and operated manually or driven by gearmotors. Bulletin AD-66A gives details. 8 pages. Duff-Norton Co., Box 1889, Pittsburgh 30, Pa. F

Circle 605 on Page 19

Vinyl-Metal Laminates

"Col-O-Vin Meets Metal" is an illustrated brochure which highlights the properties and applications of this material. Both textured and patterned vinyls in a wide range of colors are available permanently bonded to steel, aluminum, magnesium, or wood. It is decorative, durable, and easily fabricated. Actual samples are included in book. 16 pages. Columbus Coated Fabrics Corp., Seventh & Grant Avenues, Columbus 16, Ohio. G

Circle 606 on Page 19

Rheostats, Resistors, Relays

Components listed in Catalog 30 include rheostats and potentiometers, resistors, relays, variable transformers, tap switches, chokes, capacitors, and others. Among newer products are miniature rheostats, new values in molded "pots," 0.1 and ¼-w miniature resistors, extra-heavy current resistors, tantalum capacitors, and variable transformers. 32 pages. Ohmite Mfg. Co., 3630 Howard St., Skokie, Ill. J

Circle 607 on Page 19

In-Line Filters

Manned aircraft, missiles, test stands, ground support equipment, and general industrial service are among applications for T-type in-line filters, replacement filter elements, dual bowl filters, and differential pressure indicator filters. Ratings from 2 to 250 microns are described in Folder BFD-64. 6 pages. Bendix Aviation Corp., Bendix Filter Div., 434 W. 12 Mile Rd., Madison Heights, Mich. H

Circle 608 on Page 19

Locking Nuts & Bolts

Whiz-Lock nuts and bolts employ a controlled lock, torque-tension principle which features scientifically designed locking teeth. Torque required to break fasteners loose is much greater than tightening torque. Principle is described in folder. 4 pages. MacLean-Fogg Lock Nut Co., 5535 N. Wolcott Ave., Chicago 40, Ill. J

Circle 609 on Page 19

Pressure Switches

Condensed catalog reviews general-purpose pressure switches, including pneumatic and hydraulic types, high vibration models, and differential pressure units. Special application units are also discussed. 4 pages. Consolidated Controls Corp., Bethel, Conn. B

Circle 610 on Page 19

Carbon Steel Tubing

Condensed data on mechanical and physical properties, upsetting, swaging, flanging, expanding, bending, and welding of seamless or welded carbon steel tubing are furnished in Technical Data Card 142 B. Tubing is made in seamless sizes to 9⅝ in. and in welded sizes to 4 in. OD. 4 pages. Babcock & Wilcox Co., Tubular Products Div., Beaver Falls, Pa. G

Circle 611 on Page 19

Aluminum Nameplates

Brady Quik-Plates, self-bonding anodized aluminum nameplates, are used to identify, instruct, inform, and decorate. Bulletin 177-B which describes Quik-Plates lists four types of self-bonding adhesives with appropriate application instructions. 4 pages. W. H. Brady Co., 727 W. Glendale Ave., Milwaukee 9, Wis. K

Circle 612 on Page 19

Miniature Connectors

Series 1900 miniature rectangular connectors for aircraft and electronic equipment applications feature a center screw-lock with double thread action. Units offered with 34 or 104 contacts and rated 10 amp continuous are described in bulletin. 2 pages. DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 613 on Page 19

Magnetic Contactors

Class 41 20, 30, and 40-amp magnetic contactors supply across-the-line control of hermetic and general purpose motors used in air conditioning and refrigeration industries. They are rated through 550 v. Features, styles, and dimensions are covered in descriptive Bulletin 41-B1. 4 pages. Furnas Electric Co., Batavia, Ill. I

Circle 614 on Page 19

Photoelectric Control

Easy-to-use controls for industrial counting, sorting, signaling, protecting, diverting, detecting, or limiting are described in Bulletin GEA-6822. It shows how devices can simplify systems, reduce labor, and cut waste while increasing the speed of an operation. Light-beam distances for photoelectric relays range from inches to thousands of feet. 16 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 615 on Page 19

Fluid Drive

Advantages of adjustable speed Gyrol fluid drive units in flow control applications in pipeline pumping stations are related in illustrated Bulletin A519. Curves chart economy of adjustable speed vs. constant speed. Operating principles are explained. 8 pages. American-Standard, Industrial Div., Detroit 32, Mich. H

Circle 616 on Page 19

Specify the

T-J Spacemaker

for longer, more efficient cylinder service

You too—can reduce replacement expenditures—lower maintenance costs with the T-J Spacemaker cylinder line. Designed and engineered for ruggedness, and accuracy of operation, the Spacemaker assures longer, uninterrupted operation.

The T-J Spacemaker eliminates tie-rods, gives greater strength, saves space . . . and reduces costs in all push-pull operations. Immediate delivery in a complete range of styles and capacities . . . air or oil. Write for Bulletin SM 155-4, today. The Tomkins-Johnson Company, Jackson, Michigan.

With Extras . . . At No Extra Cost

1. METAL PISTON ROD SCRAPER—protects rod packing, cylinder bore and rod surface by removing all foreign particles.
2. NEW "SUPER" CUSHION for air or METALLIC SELF-ALIGNING MASTER CUSHION for oil.
3. HARD CHROME PLATED CYLINDER BORES AND PISTON RODS for greater protection and reduced wear.
4. ONE PIECE PISTON assures better alignment, longer bearing and packing life.
5. FORGED SOLID STEEL HEADS throughout entire line.
6. PILOTED PACKING GLAND with extra long bearing for additional strength and support to piston rod.
7. NO TIE-RODS TO STRETCH—gives you 360° port rotation . . . less space used . . . full strength.
8. STREAMLINED DESIGN . . . operating pressures to 200 PSI, air; 1,000 PSI oil, non-shock.

T-J TOMKINS-JOHNSON

VALVES . . . AIR AND HYDRAULIC CYLINDERS . . . CUTTERS . . . CLINCHERS

Circle 479 on Page 19

Blueprint Roll File

Staktube roll file holds up to 36 rolled blueprints, charts, drawings, or tracings. Only 15 in. square, units bolt together for easy stacking to any height. Bulletin 610 describes this file and lists available sizes. 2 pages. Stacor Equipment Co., 285 Emmet St., Newark 5, N. J. D

Circle 617 on Page 19

Check Valves

Two illustrated bulletins are descriptive of a new cartridge type check valve insert and a line of air and hydraulic check valves. Design features of these controls are shown, and specifications are tabulated for easy reference. Service range is up to 3000 psi hydraulic and −40 to 280° F. 2 and 4 pages. Kepner Products Co., 7231 W. 59th St., Summit, Ill. I

Circle 618 on Page 19

Flame Hardening Service

Included in bulletin is an engineering chart with ranges of hardness and depth usually required in flame hardening. Also shown are typical machine ways, rolls, gears, sprockets, cams, dies, and wheels which have been flame hardened for extended life up to 10 times that of unhardened products. 4 pages. Chicago Flame Hardening Co., 420 E. 151st St., East Chicago, Ind. J

Circle 619 on Page 19

Gaskets

"Gaskets for Every Service" is title of File G on standard and special gaskets available from this company. Included are recommended applications for gaskets made of rubber, neoprene, Tygon, Teflon, cork, sponge, and many other natural and synthetic materials. 4 pages. Hecht Rubber Co., 482-484 Riverside Ave., Jacksonville 2, Fla. O

Circle 620 on Page 19

Capacitor Motors

Bulletin SDA 145 contains performance and application data on a line of ½ to 15-hp capacitor motors in frame sizes from 56 to 286U. Individually tested and inspected motors are offered with manual and automatic overload protection. 4 pages. Peerless Electric Co., Electric Motor Div., W. Market St., Warren, Ohio. G

Circle 621 on Page 19

Prototype Parts

Three divisions of bulletin "Prototypes by Kotokast" describe how they fit into design program and materials available, cite case histories which show economies and flexibility in testing programs, and explain how engineers can avail themselves of this prototype service. 4 pages. Minnesota Rubber Co., 3630 Wooddale Ave., Minneapolis 16, Minn. J

Circle 622 on Page 19

Panel Clamp

Designed for quick and easy assembly and disassembly of rooms and buildings of flanged-panel construction, Clamp-Locks are vibrationproof and easily installed with a half turn of a hex wrench. Fastening jaws are made to fit any thickness. 1 page. Simmons Fastener Corp., North Broadway, Albany 1, N. Y. D

Circle 623 on Page 19

Air-Over Fan Motors

Ratings of 1 to 125 hp are available in new line of Air-Over fan motors in enclosed and explosionproof construction. Motors are designed for use in ventilating, exhaust, cooling tower, and other air-moving service. Specs and application data are given in Bulletin 2950. Louis Allis Co., 427 E. Stewart St., Milwaukee 1, Wis. K

Circle 624 on Page 19

Adjustable Bushings

Bushings described in illustrated bulletins automatically adjust in wall thickness to fill bolt or other holes completely. Bushings are used on structural bolts, as hinge or pivot pins, as bearings, and many fastening operations. 4 and 6 pages. Globe Bushing Corp., 12036 Vose St., North Hollywood, Calif. L

Circle 625 on Page 19

Magnetic Disc Brakes

Torque ratings from 1½ to 175 lb-ft are available in line of magnetic disc brakes described in Bulletin BK-4005. Usable on 1/6 to 50-hp motors, brakes feature fail-safe design, automatic reset manual release, direct-acting operation, and Thru-Shaft style. 8 pages. Dings Brakes, Inc., 4740 W. Electric Ave., Milwaukee 46, Wis. K

Circle 626 on Page 19

Bronze Gate Valve

Bronze gate valves, subject of Circular 574, are available with screwed, flange, or solder ends in ¼ to 3-in. sizes and in WOG ratings to 300 psi. Selection guidance is offered. 2 pages. Lunkenheimer Co., Cincinnati 14, Ohio. G

Circle 627 on Page 19

Molded Rubber

First of a series of mailings on molded rubber products is a specifications guide. It lists physical, mechanical, and chemical properties for neoprene, silicone, and natural rubber. Guide is offered in handy file folder. Paeco Rubber Co., 225 W. Lake St., Ravenna, Ohio. G

Circle 628 on Page 19

Servo Actuators

Custom designed electrohydraulic servo actuators described in Catalog 170 provide reliable power control for electrohydraulic servo systems. Typical uses are in aircraft, missiles and rockets, and critical industrial systems. Schematics of units in typical systems applications are shown. 6 pages. Moog Servocontrols, Inc., East Aurora, N. Y. N

Circle 629 on Page 19

Reinforced Plastics

With use of Catalog P-11, designers can select and specify the correct corrosion-resistant reinforced plastic equipment to meet any situation. It describes the wide range of applications for Haveg polyester-glass industrial equipment. Tanks, fume ducts, fans, ventilating and exhaust hoods, towers, corrugated roofing panels, and lab sinks and hoods are among items shown with pertinent technical data. 28 pages. Haveg Industries, Inc., Pla-Tank Div., West Warren, Mass. C

Circle 630 on Page 19

Circuit Breakers

Thermal-type, trip-free, push-pull and toggle switch circuit breakers are reviewed with appropriate test data in brochure. High rupture capacity, miniature, and commercial type breakers which interrupt circuits adjusted for 6000 amp at 30 v dc are covered. 8 pages. Wood Electric Co., 244 Broad St., Lynn, Mass. B

Circle 631 on Page 19

Rotary Pumps

Six brochures provide user information on internal gear rotary pumps rated to over 200 gpm. They present construction options, specifications for each model, ordering instructions, and assembly recommendations. One brochure describes hand pumps for delivering up to 20 gpm. 4 and 2 pages. Wavne Pump Co., Industrial Div., Fort Wayne, Ind. J

Circle 632 on Page 19

Fractional-HP Motors

Representative selection of fractional-hp motors covered in capsule catalog comprises universal and direct current, induction, and shaded pole motors with ratings from 1/2000 to 1 hp. Motor parts sets, blowers, and gear reduction units are also listed. 8 pages. Howard Industries, Inc., 1760 State St., Racine, Wis. K

Circle 633 on Page 19

Metal Parts Finishing

"Metal Parts Finishing Cost Guide" is compiled for determining and comparing costs involved in metals finishing procedures. It deals with on-premises and off-premises finishing of parts, and the use of prefinished metals. 6 pages. Apollo Metal Works, Dept. MD-1, 66th Place & S. Oak Park Avenue, Chicago 39, Ill. I

Circle 634 on Page 19

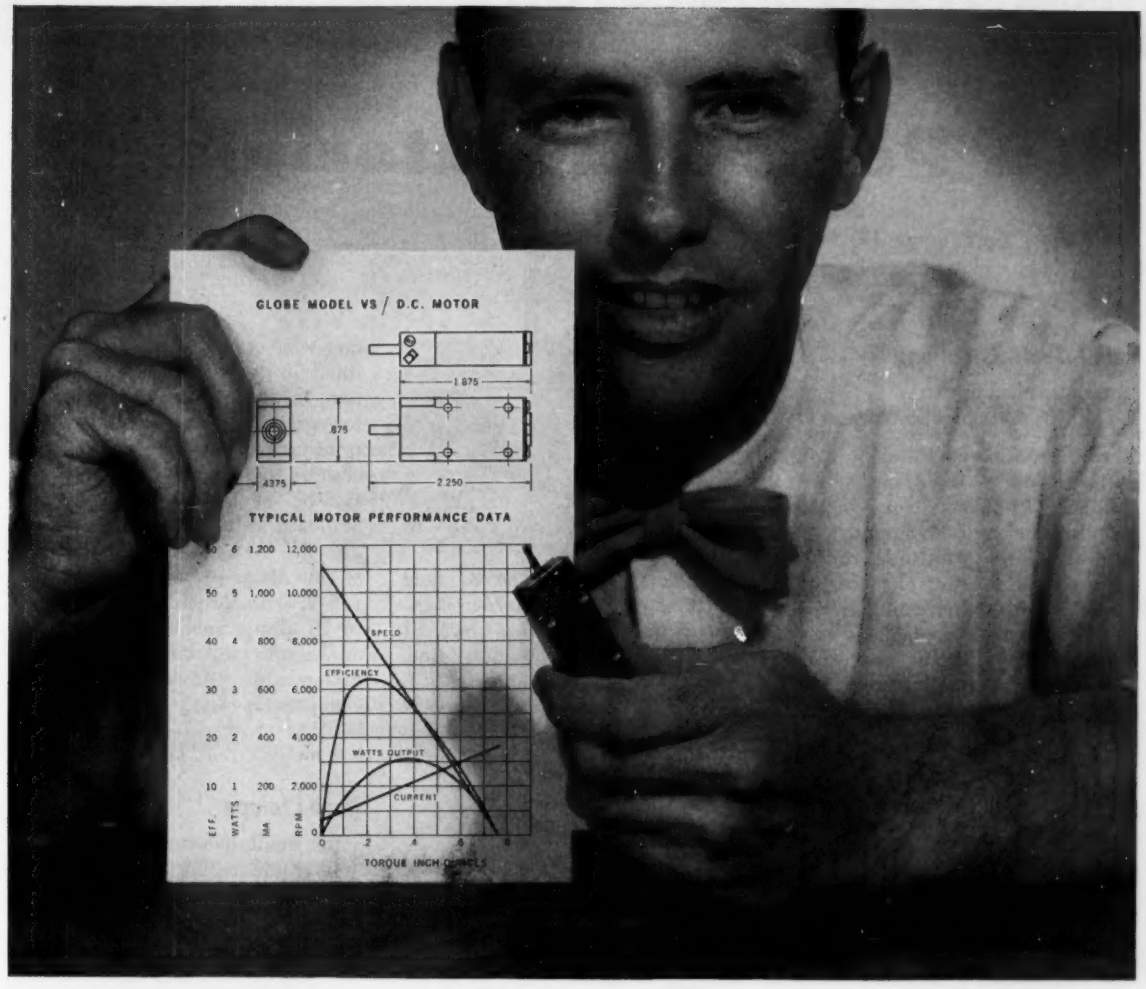
Variable Speed Drives

Basic types and various modifications of variable speed drives are shown in Bulletin 195A. Representative controls, from simple manual units to systems monitored by sensing and signaling devices, are also described. 8 pages. Sterling Electric Motors, Inc., 5401 Telegraph Rd., Los Angeles 22, Calif. L

Circle 635 on Page 19

Eyelets & Machines

Written for designers and users of eyelets as fasteners or for other purposes, 1959 Catalog outlines company's experience in such fields as metalworking, rubber, plastics, electrical, electronic, apparel, paper products, and packaging. Specifications of standardized eyelets and machines for installing them in short-run or automated setups are given. 48 pages. Request on company letterhead from United Shoe Machinery Co., Eyelet Dept., 140 Federal St., Boston 7, Mass. B



NEW FLAT MOTOR / SMALLEST YET

Globe Industries announces a new precision miniature d.c. motor, the smallest we have made. Like all Globe motors, it can be modified easily and quickly to meet your electrical and mechanical requirements. It is called the VS, and takes its place with the SS, MM and LL in Globe's family of superb quality motors.

The VS weighs 1¾ ozs., is 7/16 in. thick. A breakthrough in miniaturization, it can deliver .2 oz. in. of torque at 10,000 rpm and is the first precision motor of its size available. Multiple units can be gang-mounted in modules.

The fastest way to get full technical data on the VS motor is to phone or write direct: Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio, Telephone BAldwin 2-3741.

GLOBE

Circle 480 on Page 19

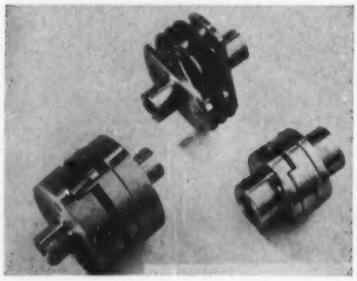
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Small Shaft Couplings

are furnished in two Oldham and one disc types

Three precision-made shaft couplings include a 1-in. diam Oldham coupling, a ¾-in. diam Oldham coupling, and a disc-type unit. Oldham couplings, consisting of two hubs and a floating element, are available with either clamp or pin-type hubs to accommodate any combination of ⅛, 3/16, and ¼-in. shafts. These stainless-steel cou-



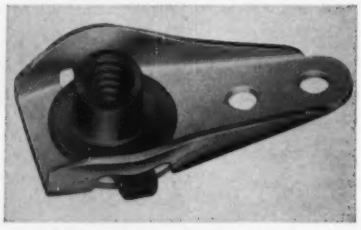
plings insure minimum backlash and tolerate a maximum of 1/64-in. lateral shaft misalignment and little or no angular misalignment. Disc-type coupling is especially suitable for applications where no backlash can be tolerated. Coupling has three beryllium-copper discs riveted to each other and to stainless-steel shaft hub, and can be supplied with clamp or pin-type hubs. Rated for maximum torque of 32 oz-in., it is free of backlash. **Helipot Div., Beckman Instruments Inc.**, 2500 Fullerton Rd., Fullerton, Calif. L

Circle 636 on Page 19

One and Two-Lug Nuts

have high strength and locking capacity

Float of ⅛ in. is provided in a new two-lug nut, No. NS223, and a one-lug nut, No. NS230 (shown). Units have high strength and locking ca-



pacity, even when used to hold structures having unusual misalignment of holes. **Nutt-Shel Co.**, 2701 S. Harbor Blvd., Santa Ana, Calif. L

Circle 637 on Page 19

Bonding Solution

treats fluorocarbons to make them bondable

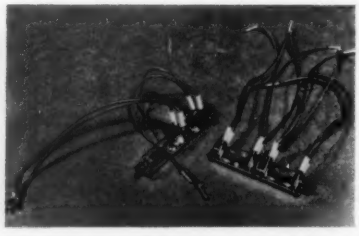
FluoroBond solution is available for treating fluorocarbons to make them bondable. Excellent bond strengths are obtained with no adverse effect on electrical properties of material in thicknesses as low as 0.005 in. Materials such as Teflon or Kel-F can be made bondable in a maximum of 15 sec by either dipping, brushing, or spray methods. Solution is available in pint, quart, gallon, and 5-gal containers. **Joclin Mfg. Co.**, Lufbery Avenue, Wallingford, Conn. B

Circle 638 on Page 19

Mercury Switch

10-deg tilt in one direction produces momentary contact

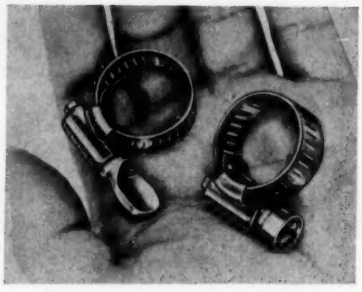
Type UZW switch controls mercury flow in such a way that a momentary-wipe contact is produced when tilted 10 deg or more in one direction, with no contact upon return to original position. Using this principle and inserting additional electrodes permits availability of a variety of circuit arrangements. Standard switch measures less than 2¾ in. in length with less than ½ in. diam. It carries 5 amp at 115 v, with inrush overloads of up to 10 amp. Smaller sizes and tilt angles are available for specific requirements. **American Designed Components Inc.**, Jericho, L. I., N. Y. D



Circle 639 on Page 19

Hose Clamps

for small-diameter hose and tubing



Size 6 worm-drive hose clamps conform to hose and tubing with diameter as small as ⅜ in. Hy-Gear clamps, with bands and housings of 18-8 gage stainless steel, are available with either standard slotted headscrew or cadmium-plated thumbscrew. **Ideal Corp.**, 435 Liberty Ave., Brooklyn 7, N. Y. D

Circle 640 on Page 19

Small Air Valves

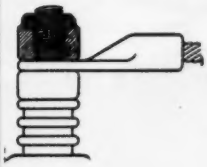
for use in vacuum or air pressures to 300 psi

Small, low-cost air valves are particularly applicable to automatic as-

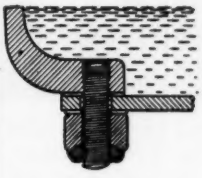
Ten fastening problems solved by ELASTIC STOP nuts

TIGHTENED AGAINST THE WORK

Vibration and impact proof bolted connections in standard applications.

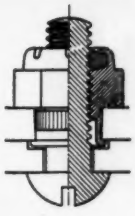


On all electrical terminals subjected to vibration in transit or operation, and for any electrical or electronic assembly where positive contact must be maintained.

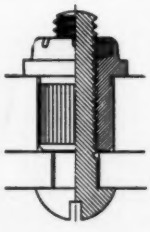


To seal bolt threads where leakage past stud threads must be prevented.

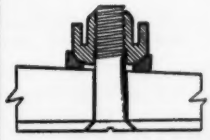
FOR MANY SPECIAL FUNCTIONS



Blind fastening applications where nut is "clinched" into sheet metal . . . becoming self-retaining as well as self-locking.

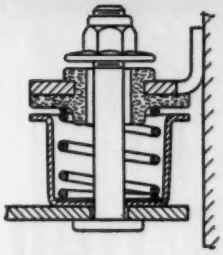


To eliminate drilling and tapping and provide steel thread strength for soft metals, an ESNA spline nut is pressed into a bored hole in casting.

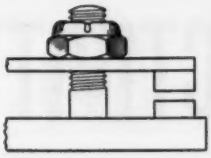


Simplified self-aligning self-locking fastener for bolting two non-parallel surfaces.

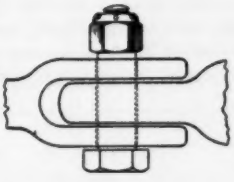
LOCKED ANYWHERE ON THE BOLT



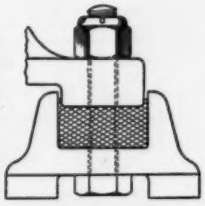
Spring-mounted connections or dynamic balancing, where nut must stay put yet be easily adjusted. (Flanged face eliminates need for extra washers.)



On make and break adjustment studs where accurate contact gaps must be maintained. Note "thin" height design for limited clearance.



For bolted connections requiring predetermined play.



For rubber-insulated and cushion mountings where the nut must not work up or down.

HOW THESE NUTS SOLVE SO MANY FASTENING PROBLEMS, ELIMINATING EXTRA PARTS AND OPERATIONS...

The red locking collar of an ELASTIC STOP® nut grips bolt threads with a perfect fit that will not loosen under severe vibration or stress reversals, and seals against liquid seepage. By bringing nut and bolt metal thread flanks into firm contact it eliminates wear producing axial play. The elastic locking action of the insert-type stop nut does not distort or gall bolt threads. It is reusable many times.

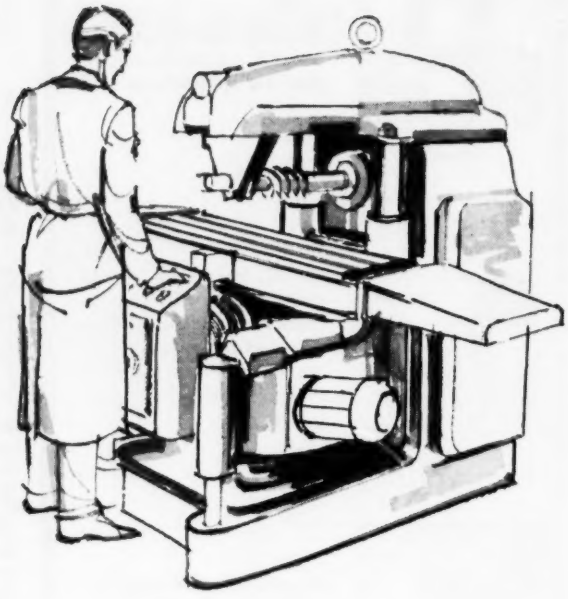
Send for the following free information: Elastic Stop nut bulletin; Rollpin® bulletin. Or enclose a drawing of your product for specific self-locking fastener recommendations. Write to Dept. N30-84.

Circle 481 on Page 19

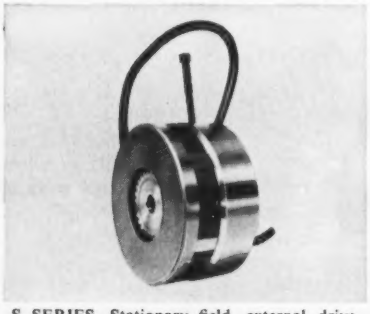
ESNA

ELASTIC STOP NUT CORPORATION OF AMERICA
2330 VAUXHALL ROAD, UNION, NEW JERSEY

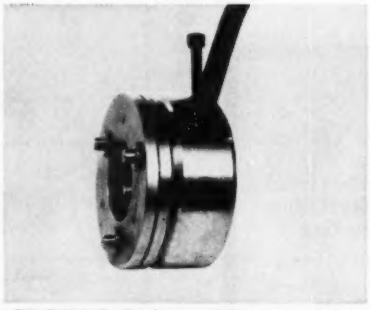
STEP UP MACHINE TOOL PRODUCTIVITY



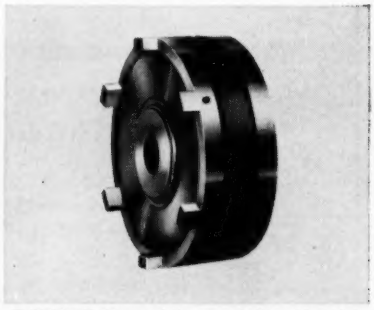
I-T-E Electro-Clutches permit instant speed or feed changes without stopping the machine or manually changing gears, chains, cams or belts. More compact than any similar clutches, they fit right in transmission boxes . . . operate under oily conditions. Clutching action is instantaneous . . . entirely electrically actuated. Sizes and types to cover practically every application from 1.8 through 13,000 lb.-ft. Send for catalog. I-T-E Circuit Breaker Company, 1900 Hamilton St., Philadelphia 30, Pa.



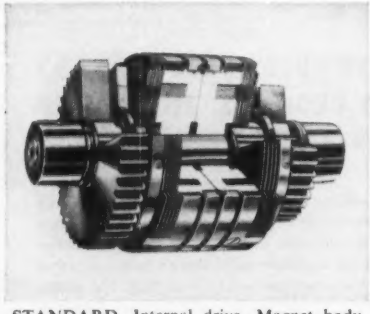
S SERIES. Stationary field, external drive, unit assembly. No brushes.



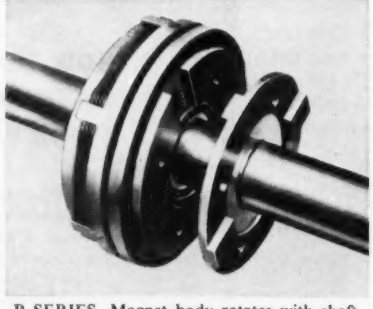
SF SERIES. Stationary field. Serrated face tooth.



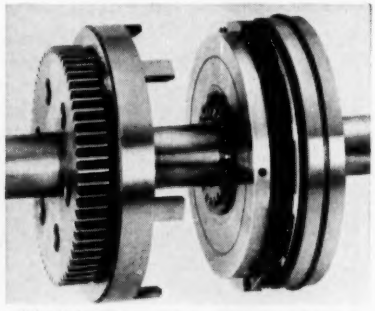
F SERIES. Serrated face tooth. Provides high torque in small space.



STANDARD. Internal drive. Magnet body rotates with shaft.



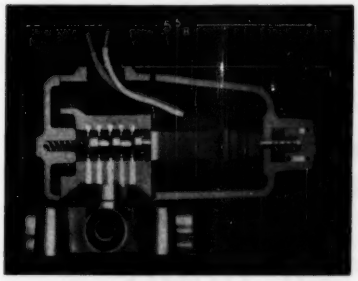
B SERIES. Magnet body rotates with shaft. Usually used as a brake.



C SERIES. External drive permits unit assembly. Facilitates machine assembly

I-T-E CIRCUIT BREAKER COMPANY

sembly machines and packaging operations. SA Junior valves operate cylinders having up to 4-in. bores in applications where high piston speeds are not a consideration. Valves are basically two types, a single-solenoid, spring-return, four-way, and a double-solenoid, momentary-contact, four-way. Design provides small physical size, relatively low air-carrying capacity, low price, high cycle speeds, and high performance. Manifolds, accessories, and mountings meet all optional applications. Valves are recommended for service on vacuum or air pressures to 300 psi. Speeds up to 450 operations per minute continuous duty, and 600 operations per minute intermittent duty are within performance range. **Numatics Inc.**, 106 S. Main St., Highland, Mich. H



Circle 641 on Page 19

Stack Valve

permits addition of other valves

Add-on type stack valve is designed for applications where hydraulic valve requirements might later increase. Two or three different types of valves can be bolted to standard unit valve if required. Standard unit is an inlet and relief valve plus two spools in a single housing. Two to six sections can be used without losing economy of initial single-housing construction. Valve incorporates a pilot-operated relief valve cartridge which can be replaced as a single unit in the field. Features of completed product include optional fourth-position detent float, three or four-way center operation, 20-gal capacity, individual check in each working section to guarantee blocking of all pressurized return flow, throttling grooves in spools for smooth operation, and special port-

CAN YOU IDENTIFY
THESE SILICONE
RUBBER SHAPES
PRODUCED BY
STALWART?
PART
COULD BE
REALLY IS
Chemical resistant tool for scraping bottom of the barrel.
Silicone gasketing for high temperature industrial oven.
Tip for pogo stick used by a faint-hearted fakir.
A chemical and temperature resistant bellows used in jet aircraft.
Last word in wrapping for a red-hot mummy.
Special Silicone winding for an electric motor.
Disguise for a half-masked refrigerator-raider.
Silicone gasket produced for the automotive industry.
All-weather decoy for duck hunters.
Heat-resistant Silicone extrusion used for oven gasket.
8301-SR

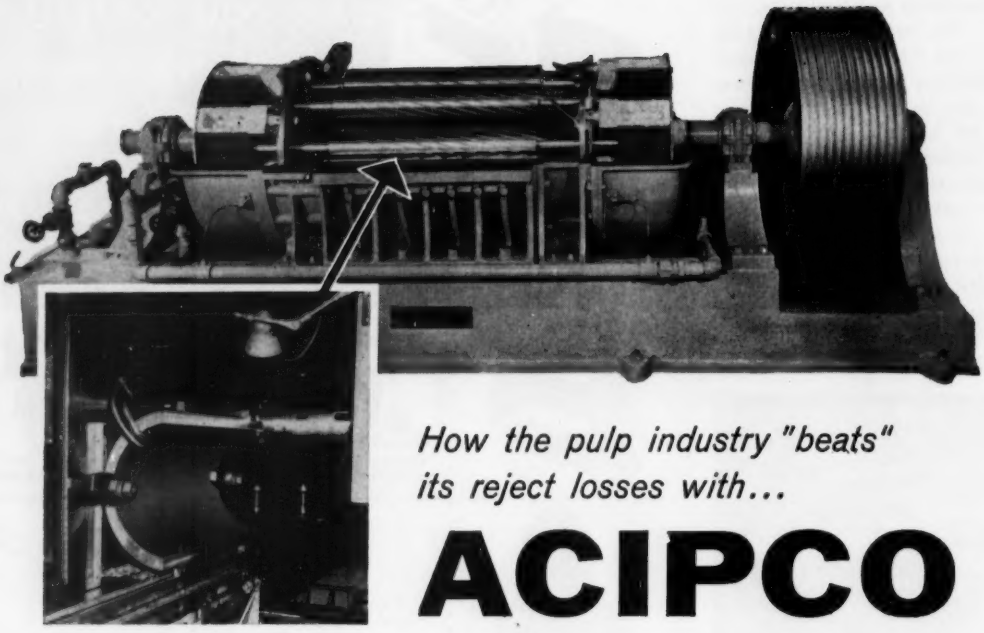
Guessing games can be fun . . . but not with rubber parts! Silicone rubber parts by Stalwart assure you high strength, maximum stability and superior dielectric qualities at temperatures ranging from −160° to +600° F. And Stalwart is the only producer of extruded and calendered *Silicone sponge parts.* Stalwart also accurately produces parts from a complete range of natural and synthetic rubber compounds to meet individual operating requirements. Write for complete information.

NEW! Send today for your copy of the Stalwart catalog.

STALWART RUBBER COMPANY

180 Northfield Road
Bedford, Ohio
Manufacturing facilities in
Jasper, Georgia and Bedford, Ohio

Circle 483 on Page 19



How the pulp industry "beats" its reject losses with...

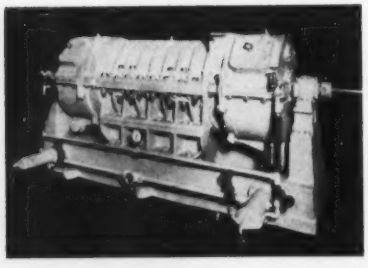
ACIPCO

stainless steel liners

Size Range Lengths up to 410" have been produced to meet modern machinery requirements. OD's from 2.25" to 50"; wall thicknesses from .25" to 4"

Analyses All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steel, plain carbon steel and special analyses.

Finished As cast, rough machined, or finished machined, including honing. Complete welding and machine shop facilities for fabrication.



Reject recovery with Anton J. Haug refiners is saving paper mills more than $7 million per year in wood alone! ACIPCO furnishes tough, durable, stainless steel liners which go inside the main casings of the machines.

In Canada, Europe, South America, Japan—as well as in this nation's largest paper mills—refiners manufactured by Anton J. Haug are saving more than 700 tons of good groundwood, sulphite and kraft rejects *each day*. This refined stock is marketed at the same price as virgin pulp—and the annual savings in wood alone is more than $7 million!

ACIPCO plays an important part in reject recovery by furnishing the stainless steel lining which goes inside the main casing of the Haug refiner. The lining, statically cast to Haug's exacting specifications, fits inside a stationary cylindrical shell.

Stock, entering at one end, travels through the machine in a helical path and is *repeatedly subjected to the pressure of high speed rolls which crush it against the liners.*

In special shapes such as this, as well as centrifugally spun steel tubes, ACIPCO castings stand up . . . under the longest, toughest assignments. If *your* application is a special one, it will be worthwhile for you to investigate ACIPCO's facilities for casting, heat treating, machining, fabricating and testing.

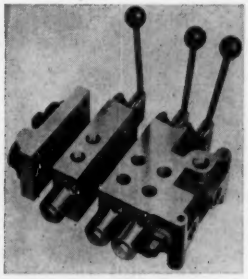
Stainless steel, carbon steel, alloy iron or special analyses—versatile ACIPCO tubes are made to solve your specific tubular metal problem. Call ACIPCO today for complete information—or for expert technical assistance.

Special Products Division

AMERICAN

CAST IRON PIPE CO.

PHONE AL 1-8121, EXT. 285 • BIRMINGHAM, ALA.



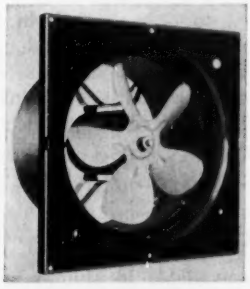
ing for easy addition of extra lines. **Webster Electric Co.**, 1900 Clark, Racine, Wis. K

Circle 642 on Page 19

Tubeaxial Fan

for ventilating electronic equipment

Low-cost, lightweight fan, designated No. 89B222, is used for ventilating cubicles, racks, and cabinets housing electronic equipment. It is recommended for use in stationary commercial equipment where shock and vibration are negligible. Mounted in an open enclosure, unit is equipped with sleeve bearings and is powered by a 1/70-hp shaded-pole electric motor operating on 115-v, single-phase, 60/50-cycle current. At rated speed, fan delivers 450 cfm of air at zero static pressure and 100 cfm at approximately 0.22 in. water static pressure. Unit



weighs 8 lb and installs in a 9-in. circular opening with 11½ x 11½-in. mounting plate. **Industrial Div., American-Standard**, 8111 Tireman, Detroit 32, Mich. H

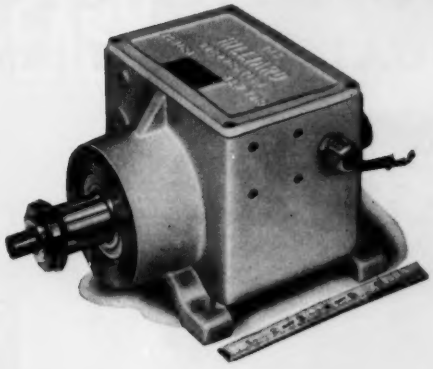
Circle 643 on Page 19

Limit Switch

can be replaced without rewiring

Heavy-duty, oiltight limit switch features a power plug which connects power cable to switch with

HILLIARD'S *New* "I.D.U."



A complete, packaged unit that gives you precise control of intermittent motion from a constant rotary power source!

Built-In features:

- Contains all the parts in one package.
- Can be installed as easily as a motor and needs only electrical connection.
- Self-lubricating for long life of 40,000,000 or more cycles.
- Operating speed from 40 to 400 R.P.M.
- Torque capacity 36 ft. lbs.
- No cumulative error in cycling.
- Instant engagement.
- Mount with direct coupling connection or use with belt, chain or gear drive.

Can be installed on existing equipment, designed into new machinery and re-used after production line changes.

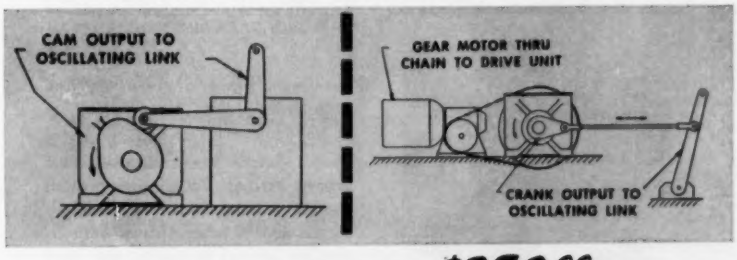
A single package unit that gives you precise control of intermittent motions . . . oscillate or repeat . . . clip and bend . . . shear or slash . . . raise or lower . . . index and position . . . from a constantly rotating source of power.

HILLIARD "I.D.U." eliminates the need of buying separate parts and assembling a "custom" machine with assorted mechanisms to control it.

"I.D.U." features highly flexible control—manual, mechanical or electrical—permitting "demand" type operations in fixed or variable cycles. A protected drive, totally enclosed in an oil bath housing, it is ideal for dusty, "steamed" or "washdown" conditions.

Write on your letterhead stating your intermittent motion problems and we will provide complete information.

Typical intermittent controls by "I.D.U"



Basic Unit Price $289.00

Optional accessories extra

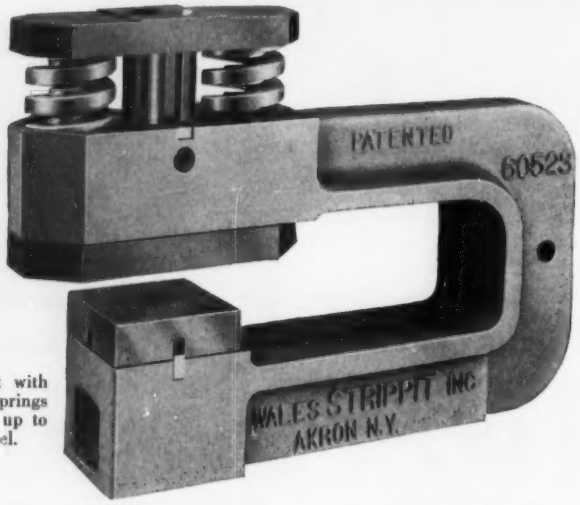
The HILLIARD Corporation

103 W. FOURTH ST. ELMIRA, NEW YORK

IN CANADA: UPTON-BRADEEN-JAMES LTD.

new STRIPPIT PUNCHING UNITS

with DUAL-RANGE capacity!



● Strippit unit with mechanical springs for piercing up to .500 mild steel.

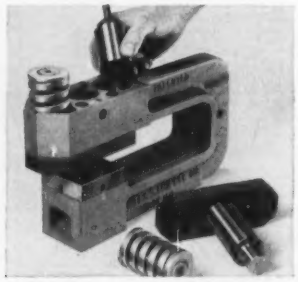
- Up to .500 mild steel, using removable Strippit mechanical springs
- Up to .750 mild steel, with interchangeable Strippit Hydra-Springs
- Convertible from .500 to .750 capacity in seconds, at minimum cost
- One heavy-duty holder for both capacity ranges
- Readily replaceable punch tips and dies — round, obround, square, shaped
- Keyed punch body keeps punches accurately aligned

USING STRIPPIT MECHANICAL SPRINGS

Max. punch dia.	Max. material thickness (mild steel)
1.375	.250
1.250	.375
1.125	.500

USING STRIPPIT HYDRA-SPRINGS

Max. punch dia.	Max. material thickness (mild steel)
1.375	.375
1.250	.500
1.125	.625
1.000	.750

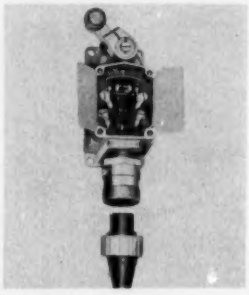


◀ Mechanical springs are easily replaced with Hydra-Springs for punching up to .750 mild steel.

WRITE TODAY for the new Strippit General Catalog. It covers all details on this and all other Strippit units... plus the savings in tooling and press time effected with the famous cost-cutting Strippit System of fabrication.

WALES STRIPPIT INC.
216 Buell Road • Akron, New York
A UNIT OF HOUDAILLE INDUSTRIES, INC.

Manufactured in Canada by: Strippit Tool & Machine Company, Brampton, Ont.



threaded coupling. Switch mechanism is replaced by removing four mounting screws, disconnecting power cable, and lifting off the switch. Factory-wired switch can then be mounted and power cable reconnected with no wiring necessary. **Square D Co.**, 4041 N. Richard St., Milwaukee 12, Wis. K

Circle 644 on Page 19

Teflon Balls

have tolerance of 0.001 in. and less

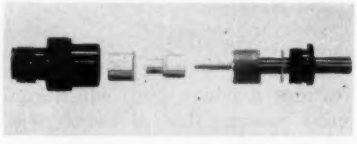
Primary applications for new Teflon balls are in pneumatic and hydraulic control instrumentation in missile and chemical-process fields, and as antifriction media in mechanical devices. Balls of virgin Teflon TFE resin have dimensional tolerances of 0.001 in. and less, and critical roundness within 0.002 in. tir. Seven diameters are available at present, from $\frac{1}{8}$ to $\frac{1}{2}$ in., in 1/16-in. increments. Six additional diameters vary from seven stock diameters by 1/32-in. increments. **Tri-Point Plastics Inc.**, 175 I. U. Willets Rd., Albertson, L. I., N. Y. D

Circle 645 on Page 19

Coaxial Plugs

are available in aluminum

Series TNC coaxial plugs, available in aluminum, are 35 per cent lighter than nonaluminum types. Designated ALTNC, they have better moisture sealing than standard plugs, and an improved cable-clamping mechanism. Assemblies available include plugs and cable jacks for



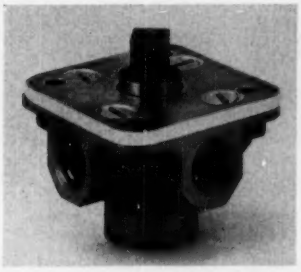
either RG-58C/U cable or ¼-in. Foamflex semirigid aluminum cable. Also available are adapters for matching two cable types to each other or to bulkhead fittings. **Cannon Electric Co.**, 3208 Humboldt St., Los Angeles 31, Calif. L

Circle 646 on Page 19

Rotary Selector Valve

is three-way, three-position unit

Manually operated rotary selector valve is a three-way, three-position unit composed of two basic parts. Spool is lap-fitted into a stainless-steel forged body that serves also as the sleeve. Design increases reliability by eliminating more than



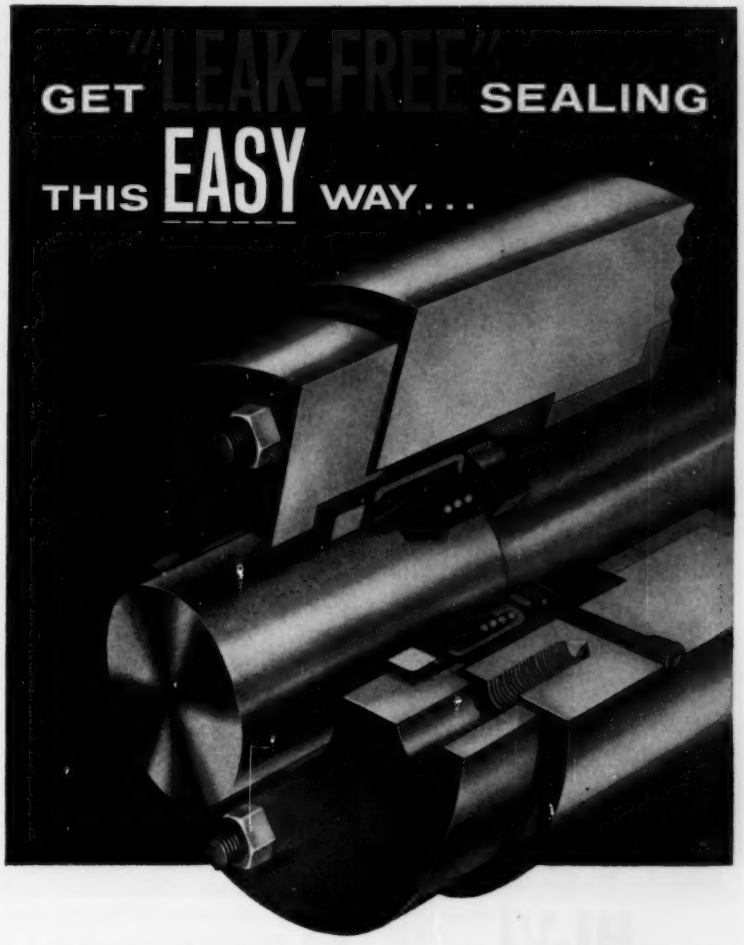
half the number of packings usually required. Integrating sleeve and body also permits miniaturizing the unit. **Hydra-Power Corp.**, Pine Court, New Rochelle, N. Y. D

Circle 647 on Page 19

Synchronous Motor

instantly starts, stops, reverses, and steps

Enclosed, permanent-magnet type synchronous motor, Slo-Syn, is adaptable for a variety of applications such as servomechanisms, automatic machines, remote control, and numerical control systems. At 60 cps, speed accurately remains at 72 rpm without gear reduction. Torque is conservatively rated at 150 oz-in. Single-pole, three-position switch gives instant starting, stopping, and reversing control because motor has only three leads. When used as a stepping or inching motor, dc impulses are converted into either 200 or 400 precise increments of one revolution of motor shaft. Rated torque is maintained for any stepping position and each step is made in-



GARLOCK MECHANICAL SEALS

Easy to install—Garlock's PK MECHANIPAK* is self-contained—no parts to "put together." Rotating portion simply slides onto shaft; stationary portion positions quickly into counterbore of gland.

Easy to maintain—Once Garlock's PK MECHANIPAK is installed, further adjustment is unnecessary. No parts of the seal move on the shaft or sleeve, eliminating wear on shaft . . . spring in seal maintains contact between sealing faces.

Easily cuts costs—Garlock's PK MECHANIPAK is designed to reduce maintenance and downtime, thus offers many dollar-saving benefits.

Available in shaft sizes from ⅜" to 3" . . . will operate at temperatures to 212°F, pressures to 150 psi, shaft speeds to 2000 fpm. PK MECHANIPAK Seals are another important part of the Garlock 2,000 . . . two thousand different styles of packings, gaskets, and seals for every need. Find out more from your local Garlock representative, or write for Catalog AD-150.

*Registered Trademark

THE GARLOCK PACKING COMPANY, Palmyra, N. Y.

For Prompt Service, contact one of our 26 sales offices and warehouses throughout the U.S. and Canada.

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

Canadian Division: The Garlock Packing Co. of Canada Ltd., Plastics Division: United States Gasket Company

Circle 487 on Page 19

UNSTICK stuck BINS

with new electro-permanent magnetic

ERIEZ HI-VI BIN VIBRATORS

Here's the newest and most efficient answer to those hard-to-move materials in sticky bins . . . designed to provide superior operating efficiency . . . exclusive pinpointed vibration gets right to the trouble spot — starts stubborn materials moving!

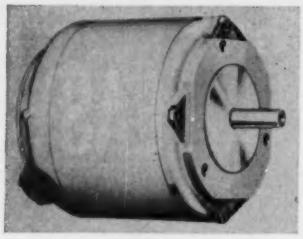
NO RECTIFIER NEEDED • COMPLETELY ENCLOSED HOUSING • GREATER VIBRATION IMPACT THAN COMPARABLE SIZE UNITS • RUGGED AND DURABLE • LOW FIRST COST • LOW OPERATING AND MAINTENANCE COST

Special Mill Mutual ACCEPTED Units for HAZARDOUS DUSTY LOCATIONS

GET BIG CATALOG . . . WRITE TODAY
Eriez Mfg. Co., 131-VA Magnet Dr., Erie, Pa.

ERIEZ

Circle 488 on Page 19



stantly. Rated input is 120 v, 40/70 cycles, single-phase, and current is 0.3 amp max at 60 cycles. **Superior Electric Co.**, Dept. SS, 83 Laurel St., Bristol, Conn. B

Circle 648 on Page 19

Plastic Foams

in pliable and rigid types

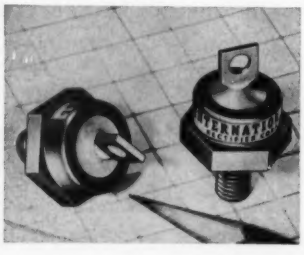
Composed of tiny, expandable polystyrol crystals, rigid and pliable plastic foams are suitable for a wide variety of applications. Flexible foam has extremely low heat transfer and water absorption, and can be rolled, twisted, or bunched. It is supplied in sheets or blocks of various shapes up to 200 ft x 4 ft x ⅛ in., 25 ft x 4 ft x 1 in., or 10 ft x 4 ft x 2½ in. Rigid foam is a nonresilient composition with most of properties of flexible type. It is available in sizes up to 8 ft x 4 ft x 20 in. **Plastifoam Corp.**, Rockville, Conn. B

Circle 649 on Page 19

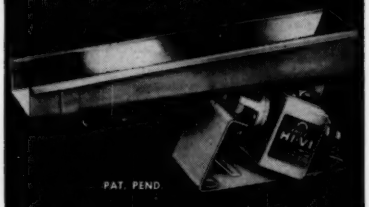
Silicon Power Rectifiers

have four-layer sealed junctions

Low-cost 25 to 35-amp silicon power rectifiers provide exceptional performance in commercial equipment applications. Junctions have a four-layer seal, designated Quad-Seal, which assures high resistance to humidity, shock, vibration, temperature extremes, and other adverse environmental conditions. Diodes feature oversized anode lug which



No Other FEEDER Like It!



electro-permanent magnetic

ERIEZ HI-VI VIBRATORY FEEDER

All-new award-winning feeder built on new concepts of design and materials. Provides accurate, controlled feed of bulk materials *automatically*. Variable feed rate, from ounces to tons. For spreading, sorting, aerating, cooling, proportioning, etc. Feeds all types of bulk materials. Increases production; reduces operating and maintenance cost.

NEW A.C. ELECTRO-PERMANENT MAGNETIC DRIVE PROVIDES GREATER FEEDING CAPACITY • NO RECTIFIER NEEDED • FULLY ENCLOSED POWER ELEMENT PROTECTED AGAINST DUST AND MOISTURE • RUGGED GLASS FIBER SPRINGS REDUCE BREAKAGE • FULLY PROVED IN PLANTS EVERYWHERE.

ALSO AVAILABLE: Economical, specially constructed units for hazardous, dusty locations . . . fully acceptable by Mill Mutual.

WRITE FOR BIG VIBRATORY FACT FILE
Eriez Mfg. Co., 131-VB Magnet Dr., Erie, Pa.

ERIEZ

Circle 489 on Page 19

Engineered by Tinnerman . . .

SPEED CLIP® lets MUFFIN-FAN® user change direction of airflow quickly...and saves 25% in mounting cost!

Some users set the Muffin-Fan, made by Rotron Manufacturing Company, to blow a cooling north-to-south breeze through their electronic or electrical equipment. Others want a south-to-north breeze. Both are readily pleased . . . the ingenious Tinnerman SPEED CLIP that holds the fan in its frame permits quick snap-out and snap-in to reverse the direction of airflow.

Rotron is pleased, too . . . the specially-designed SPEED CLIP assures positive, safe attachment of fan to frame. Eliminates possible housing breakage. Provides a unique sales advantage. AND cuts 25% off the cost of the mounting.

This exclusive SPEED CLIP is one more example of the way Tinnerman SPEED NUT Engineering Service takes a customer's idea or problem at the design stage and develops an efficient part to meet the need. And usually with worth-while reductions in parts cost.

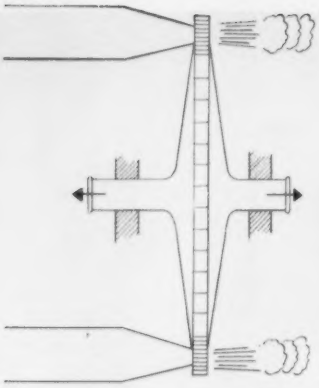
You, too, can use this service to gain all sorts of product-design and cost-cutting benefits. Call in your nearby Tinnerman sales representative to discuss SPEED NUT Brand Fasteners in your product or idea. He's listed in most "Yellow Pages" directories under "Fasteners." Or write to:

TINNERMAN PRODUCTS, INC.
Dept. 12 • P. O. Box 6688 • Cleveland 1, Ohio

TINNERMAN
Speed Nuts®

FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A. 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Muscow-Bundy GmbH, Heidelberg.



ROPER
ROTARY PUMPS

CUSTOM FLOW DIVIDER SOLVES
FUEL METERING PROBLEM
FOR TURBINE BUILDER

This multiple unit is a series of custom Roper pumping elements driven in tandem by a hydraulic motor. It accurately meters distillate or residual fuel oils to the combustion chambers in a large gas turbine. These rugged units, used on both mobile and stationary turbines, withstand extreme temperature changes during operation. This unusual application is another example of Roper's ability to tackle — and solve — difficult pumping problems.

If you have an application where a standard pump does not fit your needs, Roper can custom-design and build pumps that meet your requirements. For further information, call the factory or the Roper representative in your area.

ROPER PRINCIPLE OF ONLY TWO MOVING PARTS ASSURES EFFICIENCY . . . DEPENDABILITY

Roper Pumps are the rotary gear type — two equal size pumping gears operating in a case with proper clearance. This factor promotes long service life and optimum performance on all applications.

ROPER
ROTARY PUMPS

ROPER HYDRAULICS, INC.
248 Blackhawk Park Avenue
Rockford, Illinois

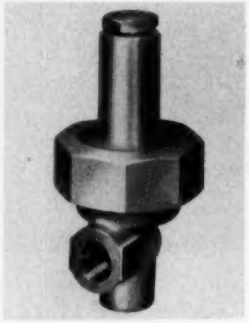
removes heat from rectifier junction, allowing unit to withstand unusually high peak-current surges. Units exhibit low reverse leakage currents (10 ma, full cycle average, at 130 C base temperature) over entire operating temperature range. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif. L

Circle 650 on Page 19

Corrosion-Resistant Valves

in relief and back-pressure types

Corrosion-resistant relief and back-pressure valves have Kel-F or Teflon diaphragms protecting upper internal parts from contact with corrosive liquids. Lower valve body and ball guide in relief valve, which



are in contact with process liquid, are PVC. Alloy seats and ball valves are available in 316 stainless steel, Milroy stainless steel, and Hastelloy C. Manufactured in ¼ and ½-in. sizes, PVC relief valve withstands pressures to 400 psi at 68 F and to 200 psi at 140 F. Back-pressure valve is available in same sizes and withstands pressures to 200 psi at 140 F. **Milton Roy Co.**, 1300 E. Mermaid Lane, Philadelphia 18, Pa. E

Circle 651 on Page 19

T-Bolt Clamps

low-cost units are for hose and duct connections

Low-cost T-bolt clamps are recommended for hose and duct connections subjected to high internal pressures, severe vibration, corrosive atmospheres, or high temperatures. Flexible stainless-steel band exerts extreme radial clamping pressure uniformly around circumference to

Circle 491 on Page 19

prevent bulges, bends, or distortion of clamp. Perfect sealing is assured even with very high internal pressures or severe vibration. Clamp has stainless-steel strip and cadmium-plated T-bolts, trunnions, and nuts. T-bolts are made in eight standard latch series with four bolt diameters. Special units are available. **Voss Engineering Co.**, 2193 W. 26th St., Cleveland 13, Ohio. G

Circle 652 on Page 19

Glass-Fiber Tubing

resists acids, alkalis, and moisture

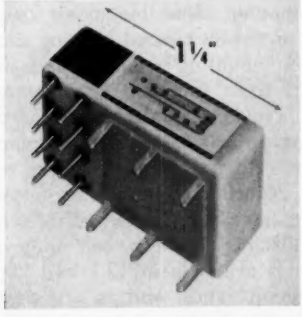
Polytube Class B polyester-varnished glass-fiber tubing is compatible with high-temperature wire enamels, glass-served wire, and polyester resins. It has excellent flexibility and resists acids, alkalis, and moisture. Tubing is also unaffected by hot or cold transformer oils. **L. Frank Markel & Sons**, Norristown, Pa. E

Circle 653 on Page 19

Miniature Relay

is side mounted and epoxy potted

Tiny relay has side mounting for printed-circuit applications and is epoxy potted for maximum shock and vibration resistance. Unit is only 1¼ in. long and less than ½



Circle 492 on Page 19→

NOW! *Adjustable Diameter and Open* THOMSON

BALL BUSHINGS

Adjustable Diameter BALL BUSHING for Zero Clearance

The BALL Bearing for *all* your **LINEAR MOTIONS**

Precision Series "A" and Low Cost Series "B" BALL BUSHING

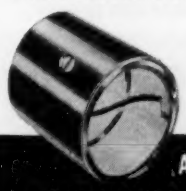
Open BALL BUSHING for Zero Clearance on Supported Shafts

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

Improve your product! Up-date your design and performance with Thomson BALL BUSHINGS!

LOW FRICTION · ZERO SHAKE OR PLAY
ELIMINATE BINDING AND CHATTER
SOLVE SLIDING LUBRICATION PROBLEMS
LONG LIFE · LASTING ALIGNMENT

The various types cover a shaft diameter range of ⅛" to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.



THOMSON INDUSTRIES, Inc.
Dept. E, MANHASSET, NEW YORK

Also Manufacturers of NYLINED Bearings . . . Sleeve Bearings of DuPont Nylon, and 60 CASE . . . Hardened and Ground Steel Shafting

HI . . . in capacity — will handle up to double the load.

HI . . . in versatility—More load with no increase in size or weight.

HI . . . in performance — Fin and fan cooled for greater capacity with less heat rise.

HI . . . in value — all new design for long life and minimum maintenance.

HI-Line reducers are available in six new series ranging from 1.33″ to 5.25″ centerdistance. Standard models in each series include vertical with high or low base, and horizontal models with worm upper or lower.

Get Your Free Catalog — 186 pages packed with useful information on gears and speed reducers

Manufacturers of gears and speed reducers - both stock and special

Ohio OHIO GEAR Company
1338 East 179th St. • Cleveland 10, Ohio

Circle 493 on Page 19

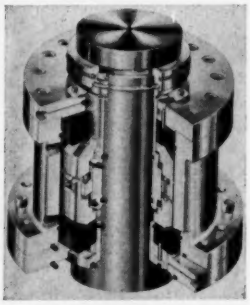
in. high. Operating temperature range is −65 to +125 C. Relay withstands shock of 100 g, linear acceleration of 100 g, and vibration of 25 g or 0.375-in. excursion over full frequency range of 5 to 2000 cps. Standard units meet requirements of MIL-R-5757C and MIL-R-25018. **Electronics Components,** 12838 Saticoy St., North Hollywood, Calif. L

Circle 654 on Page 19

Mechanical Seals

for sealed-vessel agitator shafts

Mechanipak seals are completely self-contained in a single unit for simple, quick installation. Developed for installation on sealed-vessel agitator shafts, they are available in



sizes to fit any shaft. Units prevent agitator-shaft leakage at pressures to 3000 psi and withstand temperatures over 700 F, even in corrosive environments. **Garlock Packing Co.,** 437 Main St., Palmyra, N. Y. N

Circle 655 on Page 19

Speed Reducer

permits mounting motor in fixed position

With double-reduction, offset, shaft-mounted speed reducer, called Offset Shaft-King, it is possible to mount motor in a fixed position, eliminating adjustable motor base. Use of a split, tapered bushing simplifies mounting reducer on shaft. Input shaft is offset from output hub, providing a simple means of taking up belt stretch from primary drive. Adjustable torque arms rotate reduction unit about output shaft, increasing or decreasing center distance between belt pulleys. Unit is available in 13:1 and 20:1 reduction ratios, and in six capa-

TO THE ENGINEER

who likes his switching gift-wrapped

If you want your control functions prewired, hermetically sealed in a neat package, tested out, and as ready as instant coffee, you're listening to the right people.

Because AE has a gift for wrapping up relays and stepping switches in tidy control packages of your design—or ours, if you prefer.

For instance, the control package illustrated houses an AE Type 45 Rotary Stepping Switch wired to multiple-pin headers for direct plug-in (and we supply the properly oriented socket mounting plate). This particular job has 462 connections, and could just as readily be equipped with MS connectors for insertion in matching cable plugs.

The point is, we've been wiring telephone switchboards and automatic control devices for years, and have the technique down pat. So pat that it would probably cost you less to let *us* do the job.

Besides, AE engineers are past masters at designing complex switching circuits. You can leave it to them, if you wish, to dope out the least expensive way of accomplishing the most sophisticated switching.

How about letting us in on *your* control problem? Just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. Also ask for Catalog 4083: "Hermetically Sealed Relays and Switches."

AE CAN DO

AUTOMATIC ELECTRIC GENERAL SYSTEM

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

Circle 494 on Page 19

"IMAGINEERING"

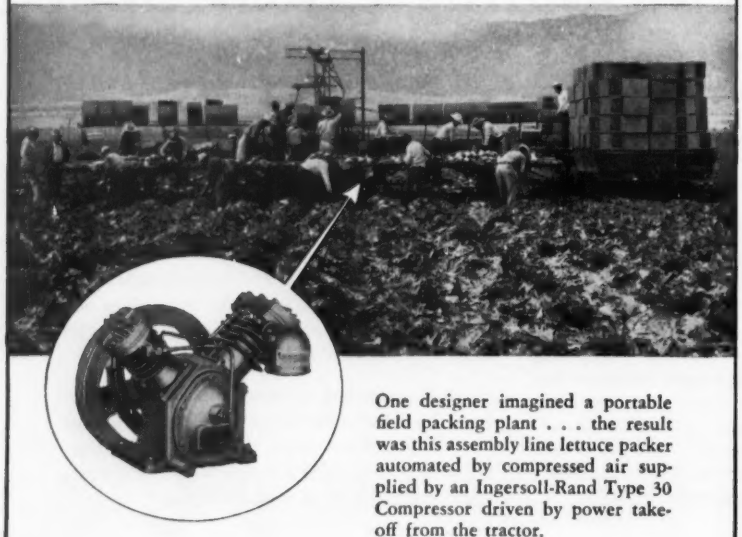
plays a big part in design planning

And if air or vacuum is required to operate some part of the planned product, Ingersoll-Rand can be of help.

Ingersoll-Rand devotes one phase of its manufacturing to a complete line of air-cooled compressors and vacuum pumps from ½ through 20 horsepower.

Thoroughly trained I-R field men can aid design people like yourself to plan an air or vacuum system into the equipment you are imagining. Then design board drawing goes easier . . . production problems are eliminated . . . and the final product is a smooth operating, trouble-free piece of machinery.

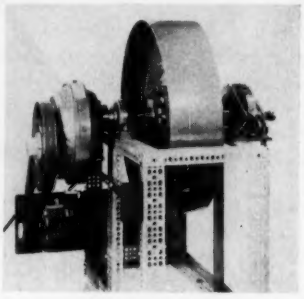
Why not consult with an Ingersoll-Rand specialist who can help you with your compressed air or vacuum problem. Call your nearest I-R branch office or write for complete information.



One designer imagined a portable field packing plant . . . the result was this assembly line lettuce packer automated by compressed air supplied by an Ingersoll-Rand Type 30 Compressor driven by power take-off from the tractor.

Ingersoll-Rand

3-810 11 Broadway, New York 4, N.Y.



cities to handle fractional to 40-hp drives. Reducer requires only a standard shaft extension of driven machine. It is driven through a short-centered V-belt drive by a motor of any make. **American Pulley Co.**, 4200 Wissahickon Ave., Philadelphia, Pa. E

Circle 656 on Page 19

Magnesia Ceramic

performs at temperatures to 4350 F

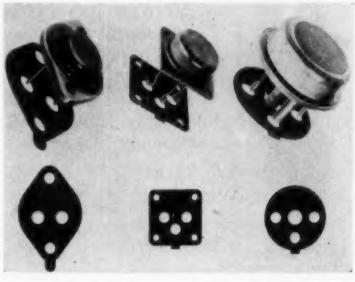
Magnesia ceramic is a dense, nonporous material of 99.8 per cent pure magnesia. It is capable of long-term operation at temperatures to 4350 F. Uniform, fine-grained structure gives it a flexural strength of 15,500 psi at room temperature. It can be slip-cast, pressed, or extruded in a variety of shapes. Melting point is over 5000 F. Material is high-fired during forming to eliminate shrinkage. **Corning Glass Works**, Corning, N. Y. N

Circle 657 on Page 19

Aluminum Insulator Wafers

have excellent dielectric resistance

Hard-anodized aluminum insulator wafers are characterized by excellent dielectric resistance and thermal conductivity superior to mica insulators. They are available for use with power transistors requiring



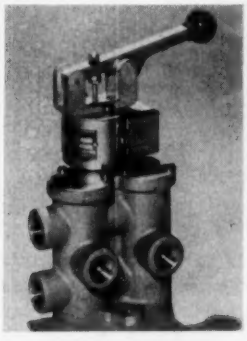
electrical insulation from chassis and dissipation of heat generated at rated capacities. In diamond, round, and square shapes to suit all bases, wafers are installed between transistor and chassis, heat sink, or other surfaces on which transistor is mounted. Wafers are extremely durable, have high abrasion and corrosion resistance. **Monadnock Mills**, San Leandro, Calif. M

Circle 658 on Page 19

Solenoid Valve

can be actuated by hand

Crescent solenoid valve is suitable for all low-pressure air systems to 150 psi. It can be actuated by hand when required, whether coil is energized or de-energized. For situations where manual control is required only in an emergency, manual lever can be safety wired to prevent accidental actuation. **Barksdale Valves**, 5125 Alcoa Ave., Los Angeles 58, Calif. L

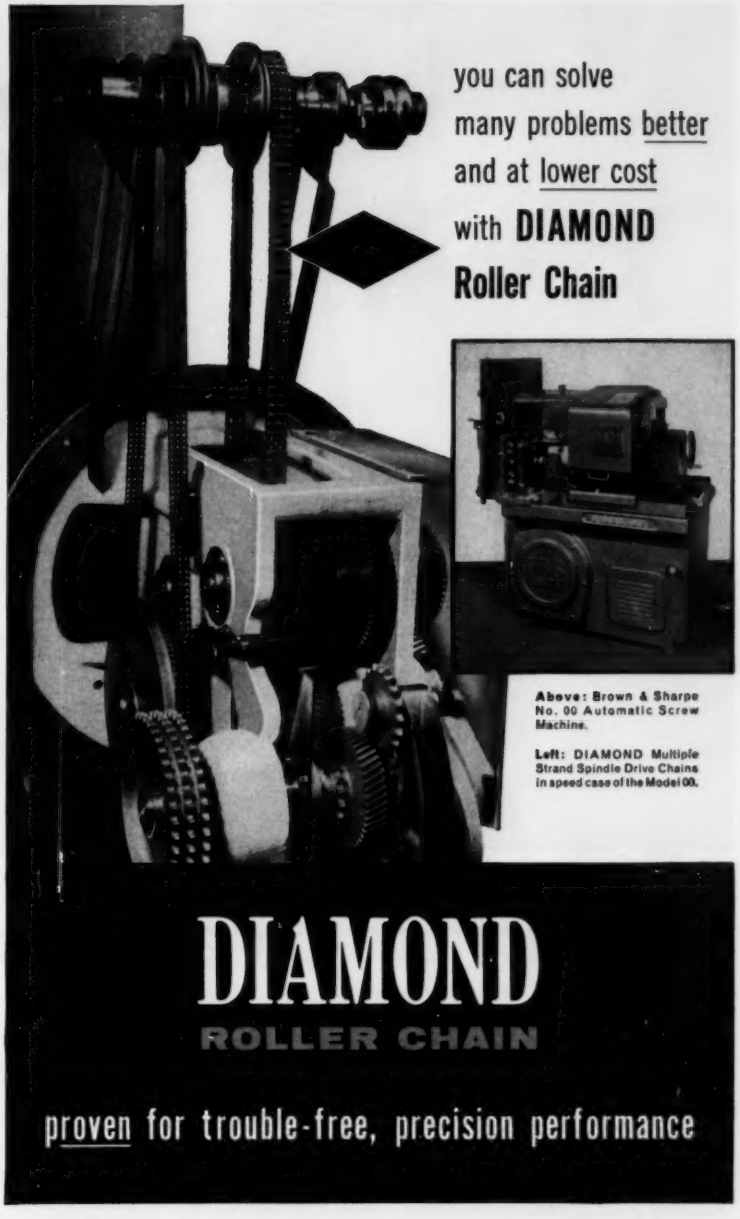


Circle 659 on Page 19

Subminiature Potentiometer

has maximum operating temperature of 175 C

Leadscrew-actuated potentiometer, designated Model 220 Trimpot, is a subminiature wire-wound unit with power rating of 1 w and maximum operating temperature of 175 C. It is available in resistances from 100 to 20,000 ohms. Measuring 3/16 x 5/16 x 1 in., unit is designed for use with printed-circuit boards and modular-type assemblies. Mounting is easily accomplished with 2-56 screws through stainless eyelets on ¾-in. centers. Terminal types are either 1½-in. gold-plated Copperweld wires or 6-


you can solve
many problems better
and at lower cost
with DIAMOND
Roller Chain
Above: Brown & Sharpe No. 00 Automatic Screw Machine.
Left: DIAMOND Multiple Strand Spindle Drive Chains in speed case of the Model 00.
DIAMOND
ROLLER CHAIN
proven for trouble-free, precision performance

DIAMOND Roller Chain is used throughout the entire Brown & Sharpe screw machine line. On motor, spindle and auxiliary drives—for flexible shaft couplings—DIAMOND Chain dependability was first proved by exhaustive tests on the new Model OO . . . subsequently confirmed on hundreds of machines now in the field.

When you specify DIAMOND you get traditional high quality that assures long operating life. Write for catalog . . . engineering service is available.

DIAMOND CHAIN CO., INC. *A Subsidiary of American Steel Foundries*

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Offices and Distributors in all Principal Cities

DIAMOND ROLLER CHAINS

Circle 496 on Page 19

How far can an engineer go at AC?

In a company so deeply involved in space age instrumentation projects . . . where you can grow through the finest "in house" training . . . where a new advanced R & D group is now operating—here, at AC, you can go as far as your imagination and initiative will take you.

Three advanced education programs can help you enhance your professional status. These are offered in addition to AC's educational assistance programs for men who wish to study for advanced degrees in nearby universities.

Program A—for recent graduate engineers—gives you a solid foundation in the theory and application of inertial guidance systems and servomechanisms.

Program B—for experienced engineers—consists of upgrading studies in inertial guidance, servomechanisms, environmental problems, engineering math and physics, plus advanced state-of-the-art courses.

Program C—for all engineering supervisors—involves management training developed by a team of AC executives and University of Chicago industrial relations experts.

AC's new R & D Group is devoted to the Research and Development of advanced systems and components. Current programs include many vital projects. Interplanetary navigation and guidance. Digital computer development. Advanced inertial sensors. Passive electromagnetic detection, surveillance and navigation systems. Guidance systems for ballistic missiles, space vehicles and aircraft.

If you are a graduate engineer in the electronics, electrical or mechanical fields, or if you have an advanced degree in mathematics or physics, you may be able to participate in these programs. For more details, write the Director of Scientific and Professional Employment, Mr. Robert Allen, Oak Creek Plant, Box 746, South Milwaukee, Wisconsin.

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AC

SPARK PLUG ❀ THE ELECTRONICS DIVISION OF GENERAL MOTORS

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

in. Teflon-insulated stranded leads. Potentiometer meets or exceeds government humidity specifications and is also impervious to other environments such as salt spray, fungus, sand, and dust. It also meets government specifications for shock, vibration, and acceleration. **Bourns Inc.**, P. O. Box 2112, Riverside, Calif. L

Circle 660 on Page 19

Manganese-Bronze Alloy

resists wear and corrosion

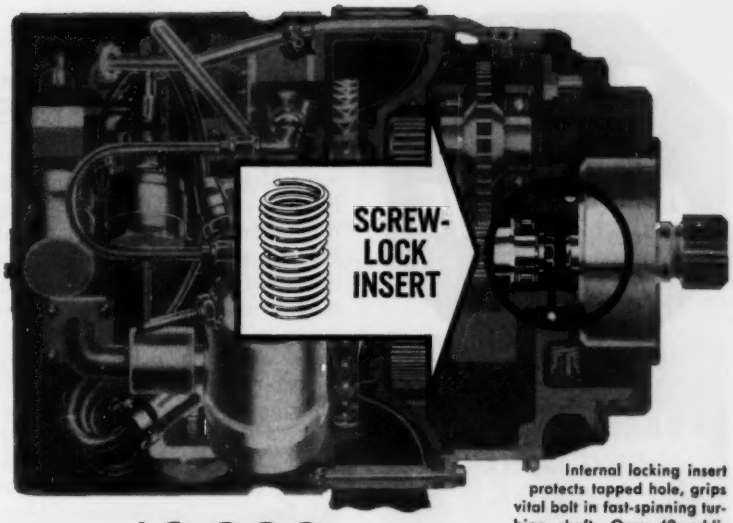
Ampcoloy 666 extruded manganese-bronze alloy is available for applications in bushings, gears, cams, shafts, and connecting rods. Alloy has excellent bearing characteristics, good machinability, and high resistance to wear and corrosion. It is supplied in a number of diameters in standard mill lengths or cut to specific requirements. Wear-resistant alloy is suitable for high production runs in automatic machines. **Ampco Metal Inc.**, 1745 S. 38th St., Milwaukee 46, Wis. K

Circle 661 on Page 19

Indicator Filters

for high or low flow

Mechanical indicator filters provide a differential-pressure signal when cleaning is required. Capable of withstanding full-line pressure of 4500 psi and operable under extreme temperature conditions, filters can be used for any fluid system in which differential pressure can be used for measurement. Fil-



Internal locking insert protects tapped hole, grips vital bolt in fast-spinning turbine shaft. Over 40 additional *Heli-Coil* Inserts insure threaded fastener security throughout the starter.

at 46,000 R.P.M.

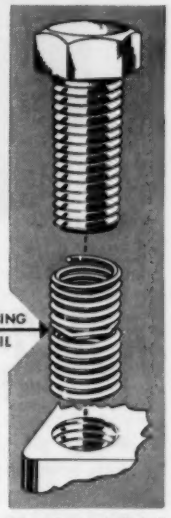
HELI-COIL®

SCREW-LOCK INSERT*

holds this vital bolt fast ...Without Lock Washers or Lock Wiring!

Even when the turbine shaft of General Electric's new AS-18 turbostarter whirls at 46,000 rpm ... the key bolt at the end of the shaft can't work or wear loose. General Electric puts a one-piece, *internal locking Heli-Coil* Screw-Lock Insert in this tapped hole, gets thread security in this important threaded assembly despite vibration met at high shaft speeds.

In addition to the critical shaft application, General Electric uses more than 40 of these *Heli-Coil* stainless steel wire inserts throughout this compact 165 hp starter for aircraft gas turbines. Production and performance benefits? Unshakeable fastener security *without* the use of clumsy, heavy lock nuts, lock washers and lock wiring ... lighter weight ... less installation cost ... faster and easier assembly and disassembly of this tiny power pack that weighs only 46 pounds! *Patented



Principle of *Heli-Coil* Screw-Lock Insert. Locking center coil grips screw in tapped hole; holds screw firmly against vibration and impact.

***Heli-Coil* Screw-Lock Inserts**

- positively lock screws and bolts against loosening under impact and vibration
- prevent thread wear, stripping, corrosion, galling and seizing
- eliminate lock nuts, lock wiring, other supplementary locking devices
- can be used in standard proportion bosses without need for redesign
- are available in a complete range of U.N.C. and U.N.F. thread sizes
- save assembly time, space, weight and cost
- meet military specs for locking torque and vibration

HELI-COIL CORPORATION
DANBURY, CONNECTICUT

HELI-COIL CORPORATION, 508 Shelter Rock Lane, Danbury, Connecticut
Send complete design data on *Heli-Coil* Screw-Lock Inserts
NAME_____ TITLE_____
FIRM_____
ADDRESS_____
CITY_____ ZONE____ STATE_____ 1772

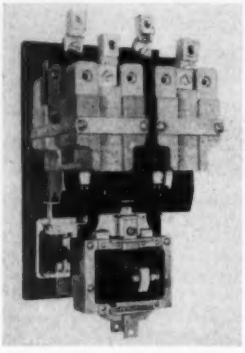
IN CANADA: W. R. WATKINS CO., Ltd., 41 Kipling Ave., S., Toronto 18, Ont.

ters employ a nonmagnetic pressure-sensitive piston which transmits linear motion to an indicating mechanism, releasing a visual button. Manual reset is accomplished by depressing indicator button until it automatically engages a detent. Filters are available with or without relief valves and bypass arrangements. Bimetallic collar contracts to prevent indicator button from operating when operating temperature falls below set limit. Filtering elements can be constructed from any type of filter media. Degree of filtration ranges from 5 to 50 mu. **Purolator Products Inc.**, 970 New Brunswick Ave., Rahway, N. J. D

Circle 662 on Page 19

Solenoid Contactors

are 150-amp, dc units



Single and double-pole solenoid contactors are designed for use in general-purpose and machine-tool controllers, and for switching lamp, battery, and other dc loads. The 150-amp, NEMA Size-4, dc units have: double-break, silver-to-silver main contacts with integral magnetic blowouts; individual molded arc-resistant hoods and arc barriers for each pole; solenoid-type power plants for fast, consistent operation. Standard coils are available for 115 and 230-v dc operation. **Ward Leonard Electric Co.**, Mount Vernon, N. Y. D

Circle 663 on Page 19

Gearmotor

is double-shaft type

Double-shaft gearmotor, identified Model 35YH29RP100, is driven by a 200-v ac, 400-cycle, three-phase

STOP ABRASIVE WEAR TO GEARS—BEARINGS AND OTHER MOVING PARTS

with LISLE *Magnetic* PLUGS

If your product has moving parts operating in a fluid, you can reduce costly abrasive wear with Lisle Magnetic Plugs.

Iron and steel particles that fracture moving parts and circulate in the oil are a primary cause of wear to gears, bearings, bushings, valves, etc.

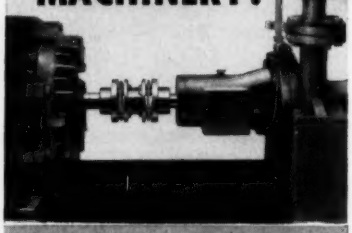
The Lisle Magnetic Plug attracts these particles, removes them from the lubricant and cuts down wear. Simply use low cost Lisle Magnetic Plugs in place of ordinary drain or fill plugs.

Write for catalog and application data

LISLE CORPORATION
Clarinda, Iowa

Circle 499 on Page 19

THOMAS FLEXIBLE COUPLINGS
Protect your PUMPS and other Indispensable MACHINERY!



NO LUBRICATION
NO MAINTENANCE
NO WEARING PARTS

Future maintenance costs and shutdowns are eliminated when you install Thomas Flexible Couplings. These all-metal couplings are open for inspection while running.
They will protect your equipment and extend the life of your machines.
Properly installed and operated within rated conditions, Thomas Flexible Couplings should last a lifetime.

UNDER LOAD and MISALIGNMENT ONLY THOMAS FLEXIBLE COUPLINGS OFFER ALL THESE ADVANTAGES:

- Freedom from Backlash
- Torsional Rigidity
- Free End Float
- Smooth Continuous Drive with Constant Rotational Velocity
- Visual Inspection While in Operation
- Original Balance for Life
- No Lubrication
- No Wearing Parts
- No Maintenance

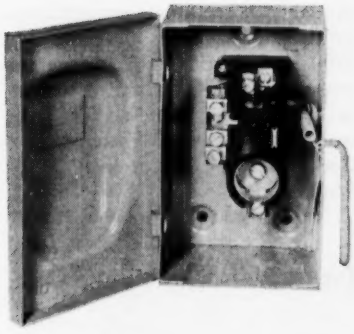
Write for Engineering Catalog

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA, U.S.A.

Circle 500 on Page 19

PRODUCT-DESIGN BRIEFS FROM DUREZ

- **New safety switch idea**
- **Phenolics in data processing**
- **What's hot in heat resistance**



A switch for fumblers

Ever try to change a fuse on a 30-amp switch in pitch darkness?

"No—and why should we?" retort the designers of many such useful devices. "Anyone who doesn't have a flashlight handy for these little emergencies is asking for trouble."

"Yes—and it was a horrible experience," breathes the designer of *this* switch. "Young son had used up all the flashlight batteries at Scout camp. Horrible. Gave me the idea for a switch *anybody* could re-fuse. It works, too."

This insight into the limitations of the average American householder is now helping to swell demand for the 30-amp safety switch pictured here. As you can see, the crossbar that actuates the contact has been moved to the back where it cannot get in the way of fumbling fingers.

To accommodate the new design, a one-piece block of Durez phenolic supplants a two-piece porcelain block. The more compact block of Durez allows extra hand-room for wiring the switch, and weighs less without loss of performance.

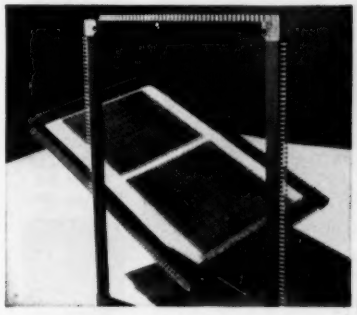
Have you an idea for a better electrical device? The odds are good that one of more than 200 Durez molding compounds can give it the exact mix of properties you want it to have. To narrow the uncertainty, see your molder or write us direct.

Jet-age abacus

With the help of Durez plastics, man can string words and numbers on wire like beads and pick them off again in millionths of a second.

His modern abacus is the IBM magnetic core memory. Thousands of tiny ferrite cores are wired into a frame like the one in the middle of this page. In an array of these core planes, stacked one atop another, electrical impulses alter the magnetic state of cores. A line of cores, some altered, some neutral, stands for a word or number, awaiting the impulse that releases it for calculation.

IBM engineers needed modern materials to bring this jet-age concept into being. The frame that supports the cores must be an excellent insulator. It must be free of internal stress that would cause warping or cracking. During assembly it must withstand the heat of dip soldering without losing its dimensions. Once assembled, it must not shrink or expand.



International Business Machines Corporation

For the core frame, designers and molder chose a mineral-filled Durez phenolic that delivers the ultimate in stability, heat resistance, dielectric strength, and moldability, meeting all requirements.

Other Durez phenolics prove their inborn versatility in the molded circuits of stepping switches, emitters, and zebra plates in new IBM accounting machines.

How much for a handle?

No, you don't really need a slide rule to design a coffeepot handle, but it helps.

This designer, at the moment, is not concerned at all with the compound-curve esthetics of coffeepot handles. He is simply figuring out how many handles his molder can make out of 1,000 pounds of which molding compound, and for how little money.

With the slide rule, it takes him only three and a half minutes to learn that his best bet for *this* handle is likely to be *Durez 1308*. Of the many mineral-filled phenolics we make, this one is in the lower gravity range. More pieces per dollar.

He has already checked into *1308's* other traits: rich black surface, uniform luster, good heat resistance (it withstands 450°F for short periods), low water absorption, flexural and tensile strengths OK.

His molder confirms the choice, for different reasons: he can get *1308* in four different plasticities, can plunger mold it, and it cures fast. Looks as if another good product is off the ground.

You don't design handles? Well, *1308* appears to fit into more heat-resistant applications than any comparable material ever developed: appliance and meter housings, wiring devices, tube bases, sockets, coil forms. The list goes on and on. But we'll stop so you can talk to your molder about *1308* for that next hot-spot job.

For more information on Durez materials, check here:

- ☐ 8-page Bulletin D400 lists properties, uses, design advantages of Durez thermosetting compounds, Hetron fire-retardant polyester resins, and Durez phenolic bonding resins.
- ☐ **"Durez Plastics News,"** mailed periodically, shows and describes latest uses of Durez materials.

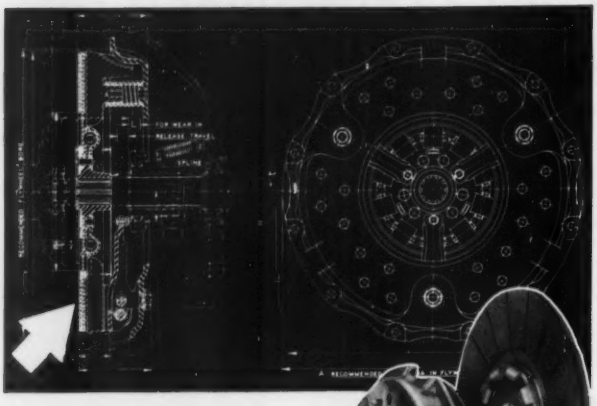
Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

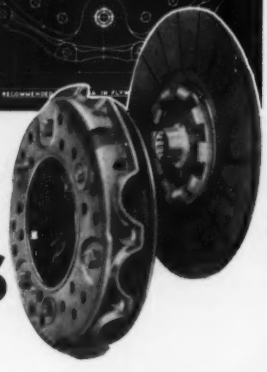
DUREZ PLASTICS DIVISION
508 WALCK ROAD, NORTH TONAWANDA, N. Y.
HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

Circle 501 on Page 19

ROCKFORD





Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

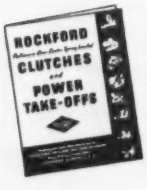
Power Take-Offs

Speed Reducers

MORLIFE® CLUTCHES

Insure SMOOTH Powerful Pick-Up in Heaviest Going

Compared to previous type friction plates, Morlife® Clutches reduce foot pedal pressure up to 50%. They assure positive engagement—with power-holding grip. Provide a degree of heat resistance and dissipation never before available. They give several times the durability for prolonging clutch life and extend the time between pedal adjustments many times as long. Let ROCKFORD clutch engineers show you how these new advantages will improve the operating ease and prolong the on-the-job life of *your* product.



SEND FOR THIS HANDY BULLETIN

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

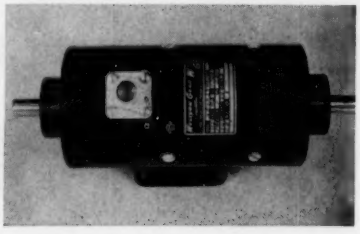
ROCKFORD Clutch Division BORG-WARNER

311 Catherine St., Rockford, Ill., U.S.A.

Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

ROCKFORD B-W BORG-WARNER

CLUTCHES



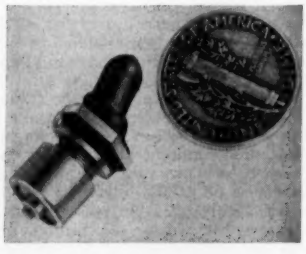
motor. Typical speeds and torques available for custom requirements by various types of gear sets are 1700 rpm at 96 oz-in. torque on one shaft, and 4700 rpm at 650 oz-in. torque on opposite shaft. **Electro Products Div., Western Gear Corp.**, 132 W. Colorado Blvd., Pasadena, Calif. L

Circle 664 on Page 19

Toggle Switch

miniature unit is only 57/64 in. long

Rugged midget SPST toggle switch, identified as T4201, has a broad application where space, weight, and durability are vital factors. Toggle can be capped with a gray silicone-rubber boot for added protection against moisture. Capped switch is identified as T4202. Switch is rated for 1 amp at 28 v dc resistive load at sea level. Switch has over-all



length of 57/64 in. and case diameter of 21/64 in. Recommended panel-mounting hole is ¼ in. **Hetherington Inc.**, 1420 Delmar Drive, Folcroft, Pa. E

Circle 665 on Page 19

Hydraulic Fluid

is fire-resistant type

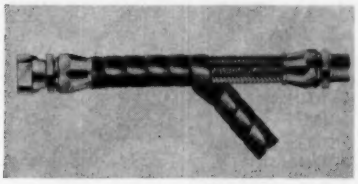
Water-in-oil emulsion-type hydraulic fluid, called Sunsafe, possesses high viscosity index of 130 with excellent film strength at high temperatures, good thermal stability, and excellent antiwear and antirust characteristics. The fire-re-

sistant fluid can be used at pressures to 2000 psi and operating temperatures to 150 F. It can be used with all centrifugal, rotary and reciprocating, or piston-type hydraulic pumps incorporating plain or friction-type shaft bearings, except where instructions indicate otherwise. Two grades are available, one for industrial machines and systems, the other for hydraulically operated mining machinery. **Industrial Products Dept., Sun Oil Co.,** 1608 Walnut St., Philadelphia 3, Pa. E

Circle 666 on Page 19

Plastic Coil Sleeve

protects hose assemblies with ¼ to 2-in. diam



Ease of installation, thermal and chemical resistance, flexibility, and long service life are among features of new plastic coil sleeve. It serves as a protector for hose assemblies ranging in size from ¼ to 2-in. diam. Lightweight sleeve is unaffected by air, water, oil, gasoline, and most other fluids, including hydraulic oils. Sleeve also insulates hot hose applications. It retains shape and flexibility under temperatures from −20 to +200 F. **Aeroquip Corp.,** Jackson, Mich. H

Circle 667 on Page 19

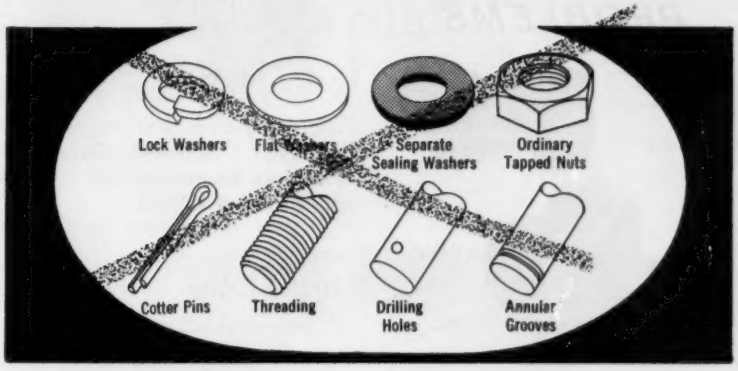
Counter and Printer

is direct read-out, swinging-head type

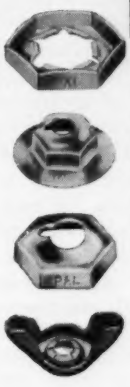
Direct read-out, swinging-head counter continuously prints digital data ranging from plus through zero to minus members, and vice versa. Counter is rated at 9000 counts per min, with printing speed of three per sec. True numerical values and symbols are printed out directly in a parallel line on tape, card, or any other print output, simplifying reading and interpretation of data. Unit employs two sets of four-digit print wheels, both positive and negative set printing

PALNUT® LOCK NUTS and FASTENERS *Eliminate*

one or more of these assembly parts or operations



–and provide compact, vibration-proof assemblies



PALNUT Lock Nuts for Threaded members

Spring tempered steel Palnuts, with the dependable double-locking thread form, are available in many stock types and sizes to meet practically any assembly need. Here are typical advantages:

- **Low cost**—less than other locking devices, often less than plain nuts.
- **Easy, fast assembly** with ordinary manual or power tools, extra fast with Palnut Magnetic Wrenches.
- **Save Parts.** One Palnut replaces 2, 3, even 4 parts according to application.
- **Save Space** by eliminating auxiliary parts.
- **Save Weight**—up to 85% reductions in fastener weight.
- **May be removed and re-used.**

FASTENERS for Unthreaded Studs, Rods, Pins, etc.

SELF-THREADING NUTS

Save threading costs. Form their own deep, clean threads while tightening on studs of any malleable material, including aluminum or zinc die-cast; also rods, shafts, wire or pins of steel, aluminum, brass or plastic. Fast assembly with standard tools. Vibration-proof grip, whether seated or unseated. Remove and reuse on same studs. Sizes for ⅛", 5/32", ¼" and ¼" dia. Write for Bulletin 585-A.

PUSHNUT® FASTENERS

Simply push on unthreaded studs, rod, wire or rivets. Strong spring grip resists removal. Save threading, grooving, drilling for cotter pins. Low in cost, fast assembly. Many types and sizes.

Write for Catalog 573-C and Free Samples, stating type, size and application.

THE PALNUT COMPANY, 75 Glen Road, Mountainside, N. J.
In Canada: P. L. Robertson Co., Ltd., Milton, Ont.

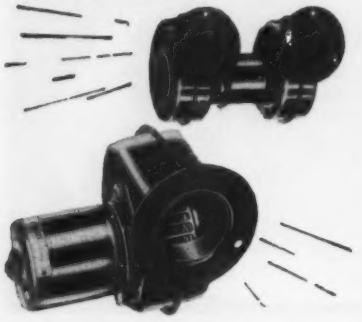
PALNUT® LOCK NUTS FASTENERS PAL®

Quick, secure fastening at low cost

Circle 503 on Page 19

put HEINZE in your designs

BLOW AWAY HOT PROBLEMS



with HEINZE D BLOWERS

Heinze D Blowers dissipate heat in a variety of cooling operations — such as in electronic equipment, vending machines, refrigeration units, induction heaters, photographic dark rooms.

Single unit delivers up to 55 cfm at 3200 rpm; double unit operates at 3100 rpm to deliver 100 cfm.

Both units are powered by long-lasting, trouble-free 2 pole induction motors, with hp ratings from 1/150 to 1/100, CW or CCW, 115V, 60 cycle. Other voltages or 50 cycle operations are available.

Send coupon for catalog.

HEINZE ELECTRIC COMPANY
685 Lawrence St.
Lowell, Mass.

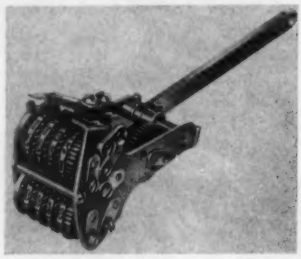
SUB-FRACTIONAL HORSEPOWER MOTORS AND BLOWERS

Heinze Electric Company, Dep't. D
685 Lawrence St., Lowell, Mass.

Please send free catalog on Heinze Sub-Fractional Horsepower Blowers and Motors.

Name & Title.....
Company.....
Street & No.....
City & State.....

Circle 504 on Page 19



out digits from 0001 to 9999 respectively. **American Data Div., American Electronics Inc.**, 75 Front St., Brooklyn 1, N. Y. D

Circle 668 on Page 19

Stretch Cables

are available in neoprene

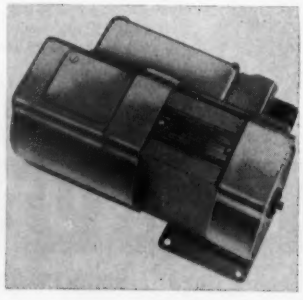
Neoprene compliance cables, available in one and two-conductor constructions, have an easy extension and return of over 200 per cent. Load of 2 lb produces a stretch of 90 per cent. Two-conductor parallel construction, SWR-2, has a resistance of 0.15 ohms per extended foot. Circuit resistance does not change with change of length of cable. Individual conductors are insulated to withstand 1000 v. Designed for any application up to 75 w, cables are suitable for communications work, patch cords and telephone systems, and missile-testing systems. Cables are durable, resist abrasion, wear, oil, and chemical attack, and have long shelf life. **Stretch Wire Corp.**, P. O. Box 893, New Rochelle, N. Y. D

Circle 669 on Page 19

Lightweight Motor

for operation on dc power sources

Totally enclosed, explosionproof, lightweight motor with a rectangular-type frame is for operation on dc power sources. Model D-3910



for longer life and no oil leakage

specify NARDA Piston Accumulators

FEATURING:

- Self-balancing piston
- Triple "O" ring seal—all three active
- Auto-relieving piston
- End caps provide dashpot action and use same seals as piston, thus requiring only one seal size for spare parts.

FOR:

- Auxiliary power
- Surge dampener
- Emergency power
- Leakage compensator
- Pressure transfer barrier

THREE MOST POPULAR SIZES:

One quart, one-half gallon and one gallon, 13", 18⅛" and 28½" long, respectively. All 4¼" diameter. (Larger sizes: 2½, 5, 10 gallons; all 8⅜" diameter.)

Standard temperature range: −40° to +200° F. Seals also available for fuels and special fluids as well as for temperatures from −65° to 400° F.

For more information about these new Narda Accumulators, as well as other models now in development, write to us at Dept. MD-2.

Some distributorships in Western and Southern states still open.

the narda hydraulics corporation
122 HERRICKS ROAD, MINEOLA, N. Y.
Subsidiary of The Narda Microwave Corp.

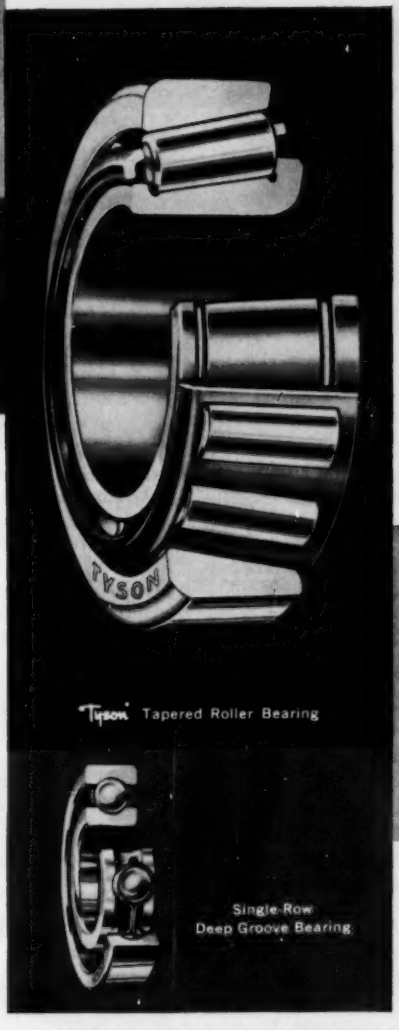
Circle 505 on Page 19

We make so many sizes... your "specials" could be our "standards"

Angular Contact Bearing

Spherical Roller Bearing

Spherical Roller Thrust Bearing



Tyson Tapered Roller Bearing

Single-Row Deep Groove Bearing

Cylindrical Roller Bearing

We regularly produce all of the bearings shown here in a tremendous variety of bores, outside diameters, and widths.

Take just the Tyson tapered roller bearing, for example. We make nearly 1,000 sizes of the single-row, straight bore type alone! Bore sizes range from five-eighths of an inch right up to a precise fourteen inches. And these figures don't include the many other sizes available in our double- and four-row types.

Yet they are all standard SKF bearings, promptly available in large quantities at competitive prices.

So, why not get full details on the most complete line in the business? Any of our twenty-five sales offices can quote you facts and figures. Just call the one near you.

5921

Spherical, Cylindrical, Ball, and Tyson Tapered Roller Bearings

EVERY TYPE—EVERY USE

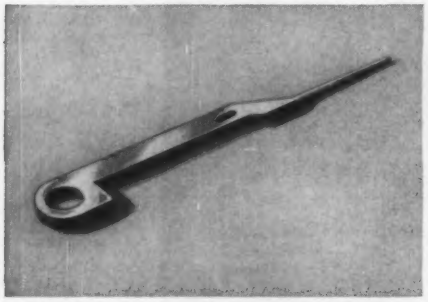
SKF®

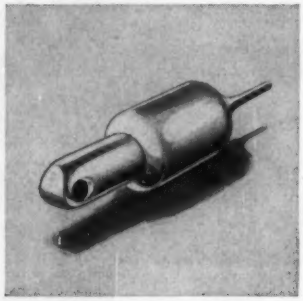
SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

*REG. U. S. PAT. OFF.

NEWS
from Torrington on
SMALL PRECISION METAL PARTS

"Custom manufacture" need not be costly—at least, as practiced at Torrington's Specialties Division. Our engineers, experienced in a multitude of methods and operations, have a knack for fitting the most efficient techniques to any small metal part in question. And these methods are not necessarily the most obvious. The motto might well be, "Precision at any cost—so long as it's the *lowest* cost possible!"





Take the control pin and sensing pin we make for a leading business machine manufacturer. Diameter of the circular section must be held to .001". Other critical dimensions require as stringent tolerances. Torrington selected a combination of stamping and swaging operations as most economical and efficient. High accuracy is achieved without tool marks or stress concentration points. Parts are tempered to RC 52-54, and are accurate to required tolerance *without grinding* and have a better finish than grinding would produce!

Then there's the pin we make for an aircraft application. Made of 440C stainless—a difficult material to work—it is finished to 8 micro-inches, again without grinding. The three radii are held concentric to .006". After tempering to RC 52-60, the part is given a .0002 to .0004" hard chrome plate.

Part of the perfection of the finished unit is the quality of material used. Skilled metallurgists have access to the most modern laboratory equipment to make sure materials meet your drawing specifications. We maintain three separate heat-treating departments, each with equipment selected for specific types of parts or materials involved. Statistical quality control methods insure the quality of product you specify. For help with

your large quantity requirements of small precision metal parts, just circle our number on the reply card, call our area salesman, or write direct to:

The Torrington Company, Specialties Division, 626 Field Street, Torrington, Conn.

TORRINGTON SPECIAL METAL PARTS

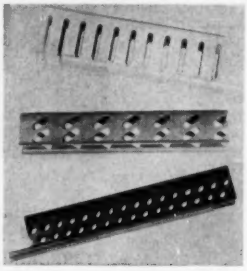
Makers of Torrington Needle Bearings

is rated ½ hp at 12,500 rpm, continuous duty, and 1 hp at 9000 rpm, intermittent duty, on 28 v dc. Length is 6.625 in., width, 3.47 in., and height, 4.25 in. Unit weighs 5.6 lb. Patented brush holder permits even brush pressure, long life, low radio noise interference, and high degree of reliability. Motor meets motor specification MIL-M-8609 and environment specification MIL-E-5272A. It is adaptable to a variety of aircraft, missile, ordnance, marine, and industrial applications such as pumps, compressors, gear boxes, actuators, winches, and hoists. **Hoover Electric Co.**, Hangar Two, Port Columbus Airport, Columbus 19, Ohio. G

Circle 670 on Page 19

Wiring Raceways

are furnished in white, gray, and colors



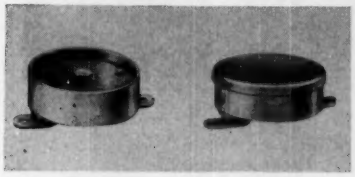
Panel Chanel wiring raceways are now furnished in white and gray as well as black, with additional colors available on special order. Colored Panel Chanel is available in full range of wire opening sizes and shapes. Made of a lightweight, durable, reinforced plastic material that withstands high temperatures, it is not subject to sagging or cold flow. It is easily cut to size and installed with standard tools. **Stahlin Brothers Inc.**, 596 Maple St., Belding, Mich. H

Circle 671 on Page 19

Bimetal Disc Thermostats

have both terminals insulated

Two new Type MX bimetal disc thermostats, designated MX-9, hermetically sealed, and MX-10, semi-enclosed, have both terminals insulated for circuits which require this type unit. The disc-type, snap-



acting units have a differential as measured on the disc of 2 to 6 deg. Units are small in size, about the size of a dime in diameter and 1/4 in. thick; weight is about 5 gr. They are furnished with closing temperatures as specified, with tolerances of ±3 F. Temperatures normally range from 10 to 260 F. Rating depends on frequency of operation and expected life. Units are available with various mounting brackets and in CR-7 crystal can. **Stevens Mfg. Co. Inc.**, P. O. Box 1007, Mansfield, Ohio. G

Circle 672 on Page 19

Insulating Tubing

of silicone rubber has improved toughness

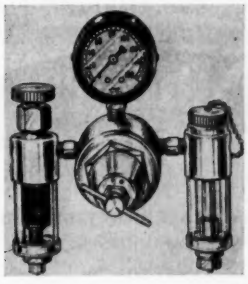
Turbo 117 silicone-rubber insulating tubing meets all MIL-I-3190, NEMA, and ASTE specifications and requirements. Toughness, low-temperature flexibility, and abrasion and heat resistance have been improved in the tubing without sacrificing desirable properties of silicone rubber. **William Brand & Co. Inc.**, Willimantic, Conn. B

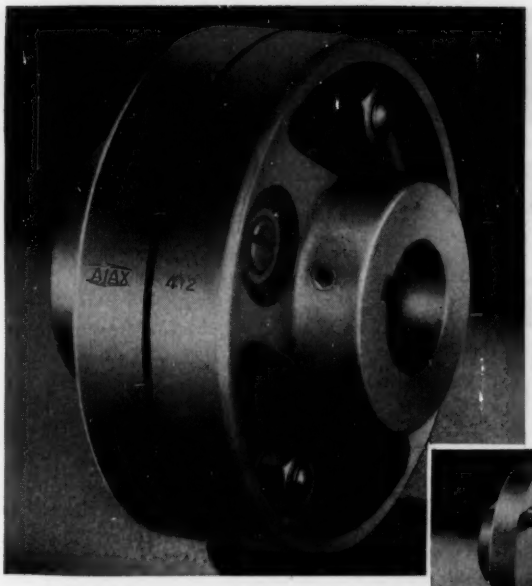
Circle 673 on Page 19

Filter-Oiler-Regulator

small combination is for air lines

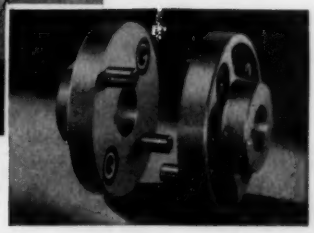
Small air line filter-oiler-regulator filters air, removes moisture, supplies an oil mist, and regulates air pressure to a desired value. Filter, capable of handling capacities to 7 cfm, is equipped with a 40-mu filter element which can easily be





Left: Periphery and face of Series 400 flanges are machined to simplify lining up with straight edge or feeler gauge.

Below: Separated halves show arrangement of 4 drive studs and rubber cushioned sleeve bearings.



AJAX

NEW *Series 400*

Normal Duty Flexible Couplings at New Low Cost

● Original equipment manufacturers and plant engineers can now have the protection of AJAX positive resilient drive for direct-connected machines at minimum cost.

New AJAX Series 400 rubber cushioned flexible couplings are particularly suited to connect motors directly to pumps, fans, mixers, speed reducers, light duty hoists, compressors, and other machines with average torques in relation to shaft diameters.

The performance of new AJAX Series 400 Couplings is based on the same proven design which has been giving satisfaction in hundreds of thousands of installations for 40 years.

Their 4 steel studs and sleeve bearings require no lubrication. Rubber cushions absorb unavoidable misalignment, and their resiliency provides a quiet cushioned drive in both directions of rotation.

AJAX Series 400 Flexible Couplings are made in 4 sizes with 1¼", 1¾", 2¼", and 2¾" maximum bore respectively with standard square keys.

Mail coupon for Catalog 67.

AJAX®

AJAX FLEXIBLE COUPLING CO. INC.
102 Portage Road, Westfield, N. Y.
Send Catalog 67 on Series 400 Couplings.

Name_____

Concern_____

Address_____

Circle 508 on Page 19

cleaned and replaced. Oiler functions automatically, furnishing an oil mist proportional to air used. Oil delivery is regulated on bottom of oiler. Regulator reduces air pressure to any selected valve and automatically retains this secondary pressure. Flow is unrestricted with minimum pressure drop. Air inlet and outlet are equipped with $\frac{1}{8}$-in. female pipe threads. Pressure gage registers from 0 to 160 psi and can be used on maximum air pressures of 150 psi and maximum temperatures of 150 F. **Oil-Rite Corp.**, 2376 Waldo Blvd., Manitowoc, Wis. K

Circle 674 on Page 19

Waterproof Connector

is available in smaller size

Bantam Flip Seal is designed for rugged service. Flexible lip overlapping male cap and seals at wire

entrances, prevent moisture penetration and provide positive sealing action against dust and dirt. Two-wire cap and connector is rated 15 amp at 125 v. It is furnished in black neoprene. **Rodale Mfg. Co. Inc.**, Emmaus, Pa. E

Circle 675 on Page 19

Switch Assemblies

are rotary-selector units with cock-and-fire actuating

No. 28AS rotary selector switch assemblies are designed for use on aircraft, electronic and computer panels, and other areas where mounting surface is at a premium. They can be provided with two to eight plastic-enclosed SPDT basic switches and two or three actuator positions. Detents are 90 deg. While moving positively from one position

SPHERCO® BEARINGS

AVAILABLE IN A COMPLETE RANGE OF SIZES

FEATURING...

- Quality engineered and produced
- Solid inserts
- Swage staking of 3-piece rod end
- Wide range of metals for races

WRITE FOR BULLETIN 257

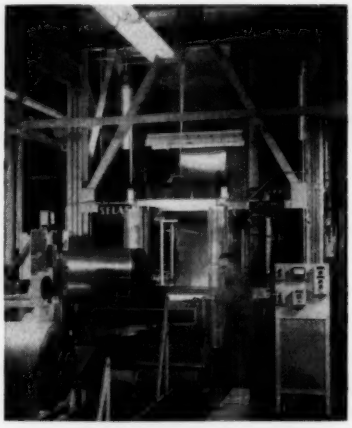
SPHERCO

A PRODUCT OF SEALMASTER BEARING DIVISION STEPHENS-ADAMSON MFG. CO.

18 RIDGEWAY AVE. • AURORA, ILL.

Circle 509 on Page 19

To meet demands for perfect finish on stainless and nickel Thinstrip®, Somers installs unique new annealing furnace.



This new Selas vertical continuous annealing furnace assures uncontaminated, commercially unmarred surfaces as well as uniform temper and faster delivery on stainless, nickel and nickel alloy Thinstrip up to 25" wide. But this is only part of the story of Somers' quality. Sendzimir rolling mills, Accu-Ray gauging plus 50 years leadership in thin gauge metals (from .010 down to .000125") are a few of the features Somers offers to assist you with your Thinstrip® problems.

Write for Confidential Data blank — no cost or obligation.

FOR EXACTING STANDARDS ONLY

Somers

Somers Brass Company, Inc.

120 BALDWIN AVE. WATERBURY, CONN.

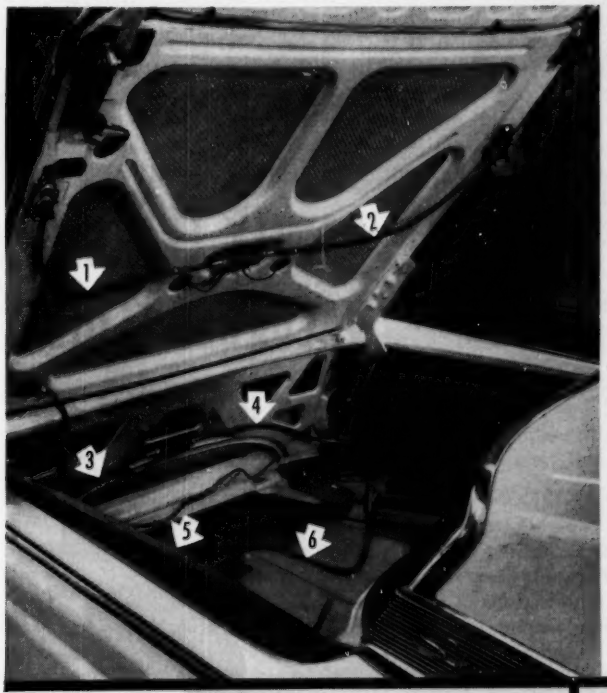
Circle 510 on Page 19

S. White DRIVE AND CONTROL IDEAS FOR ENGINEERS

Tips on better designing with flexible shafts

REMOTE CONTROL AND POWER DRIVE:

Retractable hard top simplified by flexible shafts.



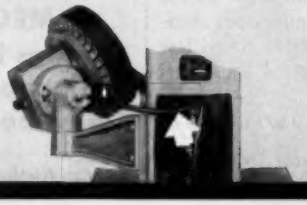
In the Ford Fairlane 500 Skyliner, the roof retracts into the trunk, and the trunk lid closes and locks. All this is done automatically, within 40 seconds. Powering this ingenious mechanism are six 3/16" high speed, remote control flexible shafts, driven by three reversible electric motors.

The use of flexible shafts enabled the designers to use only one motor to drive each pair of actuators, thus solving synchronization problems and at the same time cutting down on the number of motors needed.

Flexible shafts (1) and (2) rotate the trunk lid locking screws in and out of engagement. Flexible shafts (3) and (4) drive a pair of screw-jack actuators to raise or lower the trunk lid. Flexible shafts (5—not shown) and (6) drive a pair of actuators and their associated linkage to raise or retract the roof.

POWER DRIVE:

Powering a movable component... is easily accomplished with flexible shafts. Position of barrel type feeder on this new Detroit Power Screwdriver is highly adjustable, because it is driven by a flexible shaft. Power take-off is at the main drive motor.



COUPLING:

Solve alignment and vibration problems... with S. S. White coupling shafts — short pieces of flexible shafting without companion casings. Here is one being used between an adjustable pulley and a gear pump.

1057

S. White® IN FLEXIBLE SHAFTS

S. S. WHITE INDUSTRIAL DIVISION Dept. 4
10 East 40th Street, New York 16, N.Y.

Selection of S. S. White standard flexible shafts: complete description and application data available. **Write for bulletin 5801.**

WRITE FOR COMPLETE DATA!

Selection of specialized flexible shafts to meet unusual requirements: useful shaft data and also information on how to take advantage of S. S. White engineering services. **Write for bulletin 5601.**

PUMP DESIGN TRENDS

by Arthur A. Nichols

MANY DESIGNERS ADOPT NEW PUMP CONCEPT

Fig. 1. Three Gerotor components permit pump to be incorporated as integral part of housing or frame of mechanism, eliminate need for purchase and mounting of separate, complete pump.

Since we announced the availability of Nichols Gerotor pump component packages, more and more manufacturers are building in pumps integrally in their machines. *(Fig. 1.)*

Consisting of an inner and outer Gerotor and an eccentric-locator ring, the unit becomes a complete pump by simply boring the casting or frame of the mechanism to accommodate the locator ring O.D. and by providing porting. This design makes the main casting do double duty as the pump housing, thus eliminating a very considerable cost factor. A drive can be taken from any convenient shaft. Obviously, such a built-in pump costs far less than complete pumps purchased outside. This results from the elimination of mounting pads, couplings, lines, connections and accessory drives.

A unique combination of adaptability and reliability also account for the growing popularity of integrally designed pumps built with these Nichols packaged components. A wide range of applications include circulating or lubricating systems, scavenging oil away from sumps, powering low-pressure hydraulic systems, replenishing other pumps, hydraulic brakes and clutches.

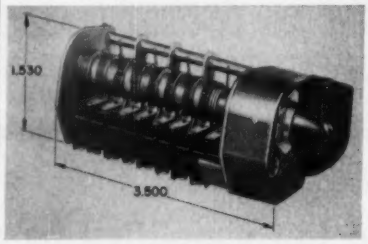
The matched elements are thus as easily built in as a simple anti-friction bearing would be. Further, the Gerotor pump is extremely flexible in its configuration and readily adapts to a wide variety of mechanism geometries. It will handle a variety of fluids at rates up to 100 gpm and pressures up to 1,000 psi.

The Gerotor pump is a positive displacement type, delivering a predetermined amount of fluid in direct proportion to speed. It is a form of internal gear pump — simple and compact in basic design, (has only two moving parts). It is lightweight, valveless, provides exceptional performance and has low wear over a long service life. It is balanced and extremely quiet in operation.

Investigate this cost saving development. Just send us information about the fluid you want to handle, rate of flow, pressure and dimensional limits. We'll provide specific recommendations, estimated costs and technical data.

W. H. NICHOLS CO.
38 Woerd Ave., Waltham 54, Mass.

Circle 512 on Page 19



to another, cock-and-fire actuating mechanism imparts a good feel of detent action and provides immediate indication of each position in operating cycle. Individual actuating levers pivot on a common rod, insuring maintained adjustment. Levers are operated by precision cams rigidly mounted on actuator shaft in desired operation sequence. Each basic switch is listed for 5 amp, 125 or 250 v. **Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.** K

Circle 676 on Page 19

Carbide Compositions

for parts with resistance to corrosion and wear

Grades K601 and K701 carbide compositions are available for corrosion-wear parts. K601 is a binderless corrosion-resistant, wear-resistant carbide of tantalum and tungsten with less than maximum corrosion resistance of platinum-bonded Grade K501. Nonmagnetic properties are advantageous for wear parts in magnetic wire and tape, particularly video tape. It also has been used successfully in making seal rings. K701, a tungsten carbide with chrome-cobalt binder, has excellent wear resistance for less severe corrosive conditions. It is more corrosion-resistant than conventional carbides and costs less than K601. **Kennametal Inc., Latrobe, Pa.** G

Circle 677 on Page 19

V-Belt

has 40 per cent increase in horsepower ratings

Improved E. C. Cord Green Seal V-belt, utilizing new materials and new developments in processing, has a 40 per cent rise in horsepower ratings over previous units. Belt allows design of new drives using

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The PERFECT SEAL
TRADE MARK

DURAMETALLIC CORPORATION
KALAMAZOO, MICHIGAN

Circle 513 on Page 19

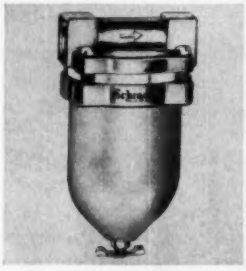
one-third fewer belts and sheave grooves, and design for installation in more limited space. Belt is produced in compass-cord construction up to 120 in. long, and in multiple-ply construction for longer belts. Both types are available in oil and heat-resisting construction with static-conducting properties. **V-Belt Dept., Goodyear Tire & Rubber Co.**, Morrill Ave. & 56th St., Lincoln, Neb. I

Circle 678 on Page 19

Filters and Lubricators

air-line units have drawn-steel bowls

Use of high-strength, drawn-steel bowls in new air filters and lubricators permits safer use at pressures well over 100 to 120 psi and temperatures to 125 F. Metal bowls



can be installed near heat-treat furnaces, paint-spray booths, and plastic-molding machines. Metal-bowled filter is recommended for installations near compressors. Bowl handles line surges as well as carry-over oil from compressor. **A. Schrader's Son, Div., Scovill Mfg. Co.**, 470 Vandebilt Ave., Brooklyn, N. Y. C

Circle 679 on Page 19

Electronic Counter

has speeds to 300 counts per min

Completely transistorized and equipped with printed circuitry, Model D electronic counter functions with accuracy at speeds to 300 counts per min. Equipped with a separate photohead, unit can be plugged into a 105 to 125-v circuit, or can be supplied for operation on 220 v ac. Applications include those where there is a high count velocity, where counter cannot contact product or package to

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newest
machines...
produced
by
EFFICIENTLY,
ECONOMICALLY
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Getting into production on new models and new machines often calls for quick action to meet desired time schedules. FAIRFIELD CAN HELP YOU!
As one of America's largest independent producers of GEARS and DIFFERENTIALS, Fairfield's facilities are complete. You get the benefits of newest high capacity machines coupled with regular big volume output in an ultra-modern plant designed exclusively for producing fine gears EFFICIENTLY, ECONOMICALLY. Check with Fairfield NOW on your gear requirements. Call or write. FAIRFIELD MANUFACTURING CO., 2307 S. Concord Rd., Lafayette, Indiana. Telephone 2-7353.
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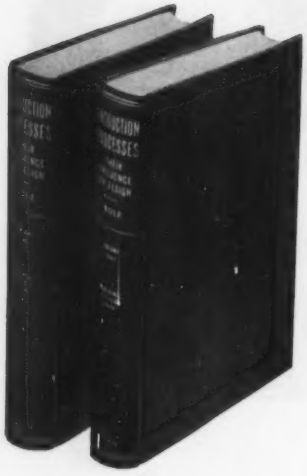

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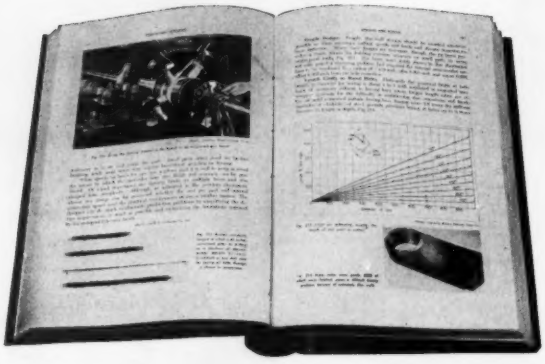

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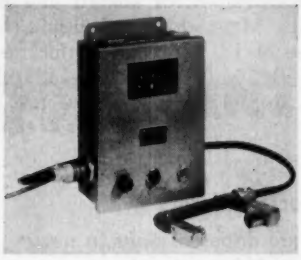

be indicated, where object is too weak or small to actuate counter, or other medium-speed applications. When teamed with proper input device or mechanism, counter also can be used to measure lengths, flow, position, and other time-count quantities. **Veeder-Root Inc.**, Hartford 2, Conn. B

Circle 680 on Page 19

Polyethylene Tubing

is bundled in a vinyl outer sheath

Instrupack consists of tubing bundles of multiple polyethylene tubes in a vinyl sheath, in lengths to 1000 ft. Tubes have excellent aging properties, good low-temperature toughness, and superior resistance to environmental applications. Outer sheath of virgin PVC is available in eight standard colors for color coding. Inside tubes are 1/4-in. OD x 0.040-in. wall with 0.045 or 0.062-in. sheath, or 3/8-in. OD x 0.62-in. wall with 0.045 or 0.062-in. sheath. **Pyramid Plastics Inc.**, 554 W. Polk St., Chicago 7, Ill. I

Circle 681 on Page 19

Pressure-Vacuum Control

is explosionproof, differential-pressure unit

Type J94K sensitive differential-pressure control is designed for use in areas where explosive gases or vapors are present, and where it is necessary to know the difference between two separate pressures or vacuums. Several system differentials are available between limits of 30 in. Hg and 40 psi, with switch differentials from 0.5 ± 0.1-in. Hg. Control is uncalibrated, and pressure settings are made by removing cover and adjusting hex-head adjustment screw. Five models are available. Switches are single pole and suitable for ambient tem-

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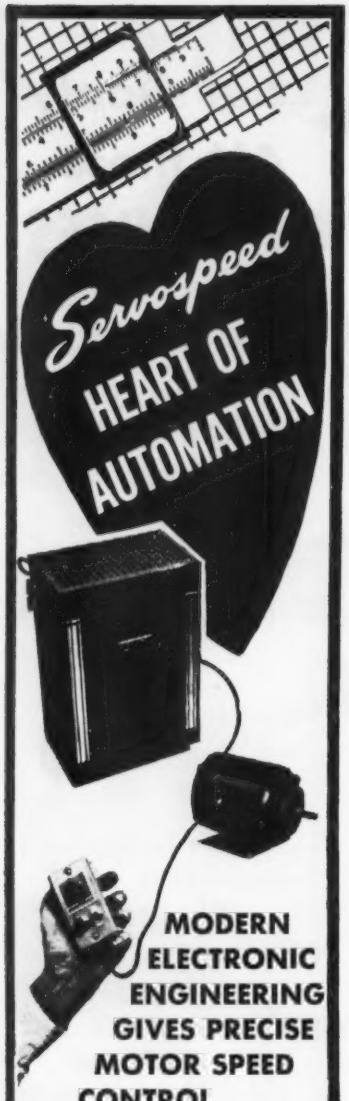
Circle 516 on Page 19



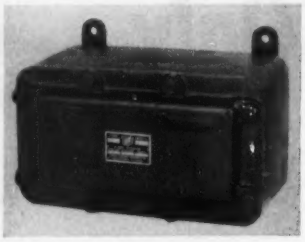
MODERN ELECTRONIC ENGINEERING GIVES PRECISE MOTOR SPEED CONTROL

1/100 — 10 H. P.

Modern industrial electronic engineering has been coordinated with electric motor design to provide a versatile means for obtaining the full possible advantage of speed control in DC motors while operated from the regular alternating current power line. Grid controlled "Thyratron" tubes are utilized for power controlled stepless variation to supply motor armature power. Patented feedback, or "Servo" circuits provide constant torque capability over wide speed ranges of as high as 60 to 1 in some models and a minimum of 20 to 1 in others.

Servospeed
DIV. of ELECTRO DEVICES, Inc.
4 Godwin Ave., Paterson, N. J
ARmory 4-8989

Circle 517 on Page 19



peratures to 100 F. They are rated 15 or 20 amp, 115/230 v ac. **United Electric Controls Co.**, 85 School St., Watertown 72, Mass. B

Circle 682 on Page 19

Gasketing Material

fiber-reinforced sheet uses fluororubber

Duroid 3400 is a fiber-reinforced sheet gasketing material which uses fluororubber. A homogeneous sheet composed of asbestos fibers encapsulated in Viton A, the elastomeric material retains dimensions and properties at continuous temperatures to 500 F and intermittent temperatures to 800 F. It also resists most of the exotic lubricants, fuels, and hydraulic fluids in use or under consideration for aircraft and missiles. Material is supplied in a sheet size of 17 x 44 in., in thicknesses of 0.015, 0.031, 0.062, and 0.125 in. **Rogers Corp.**, Rogers, Conn. B

Circle 683 on Page 19

Electric Motors

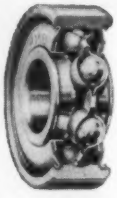
are dripproof units in new NEMA rerated frame sizes

Dripproof electric motors are available in new NEMA rerated frame sizes from ½ hp at 900 rpm through 150 hp at 3600 rpm, in frames 182 through 445 URS. Frames are rigid, seasoned, cast iron with integrally cast feet. Die-cast aluminum rotors are equipped with dual cooling fans, and entire rotor assembly is dynamically balanced. Prelubricated sealed ball bearings require no cleaning. Motors can be furnished as either three or two phase in all frequencies and commercial voltages below 600 v. **Lima Electric Motor Co. Inc.**, Dept. 139, Lima, Ohio. G

Circle 684 on Page 19

RMB FILMOSEAL BEARINGS

"Big Bearing" Construction in High Precision Miniature Sizes



Sizes from .1875" OD— 0.0550" Bore

RMB Filmoseal Miniature Ball Bearings have all the features of a big bearing including:

- Deep groove races
- Balanced two-piece or snap-type ball retainer
- Non-rubbing capillary oil seal
- Precision tolerances

Available in ABEC-5 and ABEC-1 tolerances, Filmoseal bearings combine all the advantages of sealed bearings with the rotational freedom of open bearings. There is no mechanical contact between rotating and stationary parts—lubrication is retained and foreign matter is excluded by an oil encased, non-rubbing capillary seal.

Fifteen different sizes are available for prompt delivery with experimental quantities ready for immediate shipment from stock. Filmoseal bearings are just a few of the complete RMB line of miniature ball and roller bearings. They're described in the RMB catalog which we'll be glad to send to you on request. Write for your copy today.

LANDIS & GYR, INC.

45 West 45th Street New York 36, N. Y.

Circle 518 on Page 19

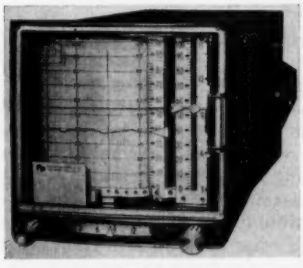
ENGINEERING DEPARTMENT

EQUIPMENT

Strip-Chart Recorder

holds 1-month ink supply without need for refill

Improved 4-in. strip-chart recorder, Mark III, features modified inking system that provides a 1-month record without refill. New pen mechanism provides a bolder, more uniform line over entire chart width. Reinking is accomplished without interfering with movement of pen parts. Unit also provides a flip switch for reversing controller action from air-to-open to air-to-close. Other features include wide-visibility plastic door, built-in damping



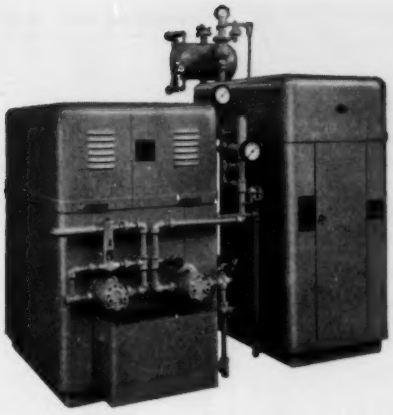
of pneumatic-input signals, fused chart motor. Unit has a 14-hr visible chart record. **Fischer & Porter Co.**, 143 Jacksonville Rd., Hatboro, Pa. E

Circle 685 on Page 19

Processing Unit

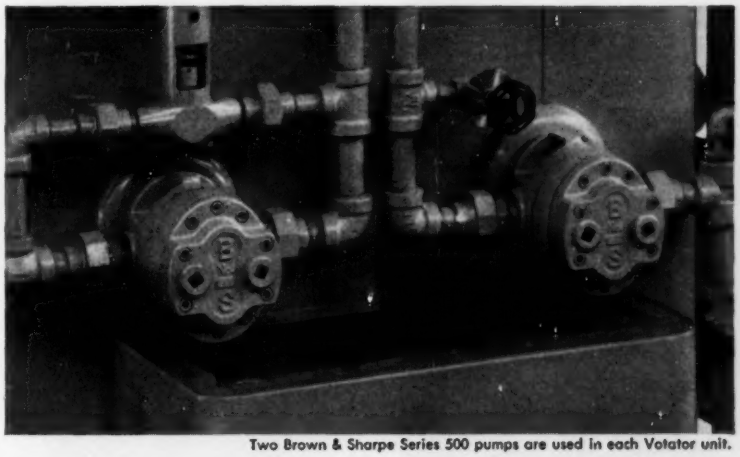
prints to 27 in. wide

Anken 27 processing unit handles engineering drawings, maps, and other large records and documents to 27 in. wide by any length. When using processor with Plenacopy solution and paper, copies of blueprints can be made in one operation. Using blueprint and shooting through it directly onto paper produces a black-on-white working print. Negative microfilm can also be projected onto Plenacopy paper and processed in machine for enlargements up to 27 in. wide by any length. Machine can also be used



Votator chilling and plasticizing units are widely used in the manufacture of vegetable shortening and lard — manufactured by Girdler Process Equipment Division, Chemetron Corporation, Louisville, Kentucky.

Why "Votator" unit designers choose Brown & Sharpe Pumps



Two Brown & Sharpe Series 500 pumps are used in each Votator unit.

Problem: Designers of these processing units for shortening require pumps that are built with unusually close tolerances between moving parts . . . yet are inexpensive. Backward slippage of hot oil and semi-liquid shortening, at pressures of 250-300 psi, must be held to a minimum. On top of all this, Votator pumps must last a long time — handling some 1,000 to 10,000 pounds of product per hour.

Solution: Brown & Sharpe Series 500 pumps are built into each Votator unit, and have been for 15 years. They are economical "stock" models, quickly available in all sizes needed — maintain rated pressure with very low slippage — provide unusually long in-service life.

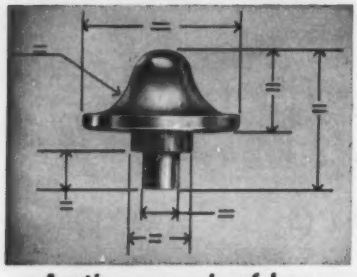
Idea: For the best solution to any pump problem — write Hydraulics Division, Brown & Sharpe Mfg. Co., Providence 1, R. I. — or contact your nearest B & S engineer-representative. Brown & Sharpe makes gear, vane and centrifugal pumps to handle more fluids than any other manufacturer.

Brown & Sharpe
PRECISION CENTER

Circle 519 on Page 19

Manufacturers of Cold Headed Fasteners Since 1888

OVER **10** TIMES THE RATE AT **50%** SAVING IN RAW MATERIAL



Another example of how Hubbell Cold Heading produces Better Parts at Faster Speeds, at Lower Cost

THE PART:
Click Button

THE MATERIAL:
Brass

THE METHOD:
Hubbell cold heading in place of screw machining.

THE RESULT:
This brass click button was machined previously from bar stock, involving several different operations that removed nearly 50% of the total weight of the original stock . . . a wasteful, time-consuming, costly process.

Hubbell now produces essentially the same part at tremendous savings in time and material cost.

a. Production is increased from the original rate of 5.5 pcs. p.m. to cold heading rate of 60 pcs. p.m.

b. Labor, overhead and material cost has been reduced 36%.

c. The finished part is stronger, more accurate, with greater uniformity.

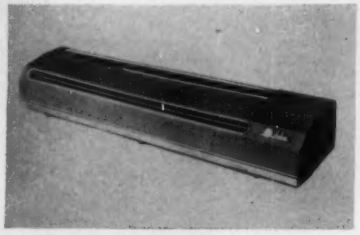
Hubbell Cold Heading may provide equally dramatic results for you. Whether it is presently cold headed or not, send blueprint of part or sample for analysis and estimate.

HARVEY HUBBELL, Inc. *Machine Screw Dept.*
Bridgeport 2, Connecticut

Kindly estimate on the enclosed sample (blueprint) Quantity _____

Name _____
Title _____
Company _____
Address _____

Circle 520 on Page 19



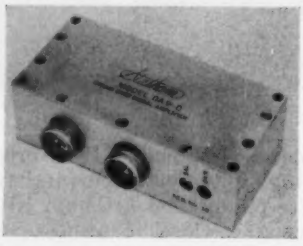
with diffusion transfer papers for making large single-copy reproductions or proofs, as well as for either film or transparent intermediates for diazo reproductions. **Anken Chemical & Film Corp.**, Newton, N. J. D

Circle 686 on Page 19

Signal-Amplifier System

combines power source and signal amplifier

Designed to save space and weight while reducing system complexity, Model CA9 airborne strain-gage signal-amplifier system operates in ambient temperature range of −65 to +165 F, and withstands 35 g vibration and 100 g shock. Dimensions are 3.87 x 1.87 x 1.16 in. Operating from 28-v dc (nominal) input, and supplying internal regulation, package combines both power source for excitation and signal amplifier, with self-contained balance



and gain controls, delivering 0-5 v dc output. Frequency response is 0 to 2000 cycles. **Statham Instruments Inc.**, 12401 W. Olympic Blvd., Los Angeles 64, Calif. L

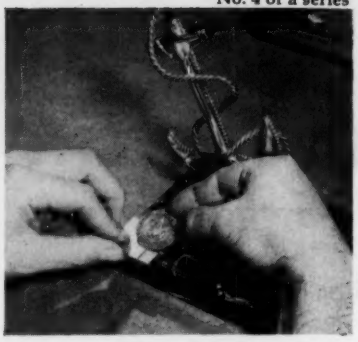
Circle 687 on Page 19

Magnetic-Tape Recorder

has low flutter characteristics

FR-600 analog magnetic-tape recorder provides wide-band recording techniques for both fm and direct recording. Unit has low flutter characteristics. Special head design and advanced electronics permit

(Advertisement) No. 4 of a series



Eastman 910 Adhesive solves another production bottleneck

The L. G. Balfour Company, of Attleboro, Mass., manufactures trophies, award placques and fraternal jewelry.

Methods of assembling a wide variety of materials quickly and simply are of prime concern in the manufacture of such products.

Balfour has found an answer in quick-setting, high-strength Eastman 910 Adhesive.

With this new adhesive, Balfour obtains virtually instantaneous bonds... eliminates soldering on many items... cuts up to 15 hours' processing time to speed delivery of rush orders.

As for strength, a medallion secured to an onyx base with one drop of adhesive *could not be removed without pulling away some of the onyx itself.*

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

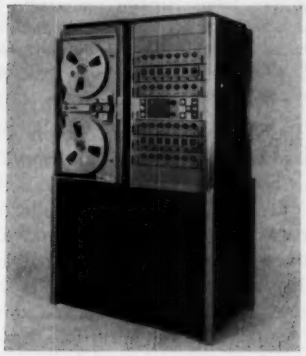
Eastman 910 Adhesive is simple to use. No mixing, heat or pressure is required. Upon spreading into a thin film between two surfaces, setting begins immediately. With most materials, strong bonds are made in minutes.

What production or design problem can this unique adhesive solve for you?

For a trial quantity (⅓-ounce) send five dollars to Armstrong Cork Company, Industrial Adhesives Division, 9108 Dean Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Division, Dept. M-8, Kingsport, Tenn.

Circle 521 on Page 19

direct recording of frequencies as high as 250 kc. Fm response from dc to 20 kc within ½ db is double that previously available. Use of air-lubricated tape guiding instead of fixed or rotating guides eliminates physical contact between guide and tape. Friction is reduced, giving faster starts, reduced flutter, and less tape wear. Laboratory-type instrumentation recorder offers all solid-state electronics. Tapes of ½ and 1-in. are easily interchangeable



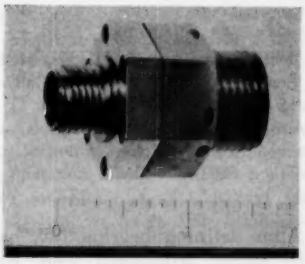
and both 10½ and 14-in. reels can be used. **Instrumentation Div., Ampex Corp.**, 934 Charter St., Redwood City, Calif. M

Circle 688 on Page 19

Miniature Accelerometer

for −70 to +230 F temperature range

Model 2224 accelerometer is designed for applications where size and weight of instrument are critical. Subminiature model is ½ in. high and weighs 9 grams. Frequency response, ±5 per cent, is 2 to 6000 cps with amplitude linearity of 1 per cent and temperature range of −70 to +230 F. Insulated mount-



ing stud provides complete isolation from ground loops. **Endevco Corp.**, 161 E. California Blvd., Pasadena, Calif. L

Circle 689 on Page 19

Chace

THERMOSTATIC BIMETAL

ACTUATES ANOTHER PRECISION PRODUCT

the CTS TUBESAVER

A PRODUCT OF
CHICAGO TELEPHONE
SUPPLY CORP., ELKHART, INDIANA

Here's an efficient little protective device for television circuits, manufactured by Chicago Telephone Supply Corporation. The Tubesaver consists principally of a thermistor in the line circuit to eliminate the current surge when the set is turned on and a thermo-delay bimetal switch in the B+ circuit which remains open until the tubes are fully warmed. The design of the bimetal element permits the set to warm up 15 to 45 seconds before the plate voltage is applied. Such protection has led some of the manufacturers to increase warranty time on all of the components, as the Tubesaver eliminates the damaging electrical surge on cold tube filaments, and prevents "cathode stripping" by allowing a slow warm-up.

The fantastic growth of the television industry, with millions of sets being produced each year, with constant improvement in design and quality, yet with generally lower and lower costs to the consumer, is a concrete tribute to the engineering, development and production genius of the manufacturers. We're proud to point out that Chace has kept pace with the best in the industry, providing the precious bits of thermostatic bimetal which actuate such devices as the Chicago Telephone "Tubesaver." Our third of a century of experience in the creation of such critical elements is one of the most important qualities you get in Chace Thermostatic Bimetal, second only to the unvarying precision of our alloys, our bimetal combinations and our fabricating of the elements, strips or coils we make to your specifications.

If you have a new temperature responsive product or one in the "thinking" stage, send for our booklet, "Successful Applications of Chace Thermostatic Bimetal." It contains many pages of useful engineering data and design information on our more than 30 different types of bimetal.

W. M. CHACE CO.
Thermostatic Bimetal
1616 BEARD AVE., DETROIT 9, MICH.

Circle 522 on Page 19

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Recent Books

Research Techniques in Human Engineering. *By Alphonse Chapanis, professor of psychology and industrial engineering, The Johns Hopkins University; 316 pages, 6 by 9 in., clothbound; published by and available from The Johns Hopkins Press, Homewood, Baltimore 18, Md.; $6.00 per copy.*

Based upon a monograph prepared for the three military services, this book has two aims: To describe methods available for collecting trustworthy data on men and machines and the relationships between them, and to discuss principles and guide lines about ways of doing dependable studies on people. Examples of both good and bad studies are discussed as a method of explaining principles.

New Standards

American Standard B3.10-1959, Requirements for Instrument Precision Ball Bearings. *11 pages, 8½ by 11 in., paperbound, stapled; published by and available from American Standards Association, 70 East 45th St., New York 17, N. Y.; $1.00 per copy.*

Characteristics which define an instrument-precision ball bearing are listed. The standard also establishes size classifications for selective assembly, boundary dimensions and tolerances, and internal radial clearances.

American Standard B3.11-1959, Method of Evaluating Load Ratings for Ball and Roller Bearings. *19 pages, 8½ by 11 in., paperbound, stapled; published by and available from American Standards Association, Dept. PR 81, 70 East 45th St., New York 17, N. Y.; $1.75 per copy.*

After defining bearing life, basic load rating, equivalent load, basic static rating, and static equivalent load, the standard presents formulas for calculating these values for different types and sizes of bearings. Uniform test procedures and statis-

tical methods for determining load-carrying capacity and expected fatigue life of ball and roller bearings are established. Both dynamic and static capacity of radial and thrust-type bearings are covered.

ASTM Specifications for Steel Piping Materials. *507 pages, 6 by 9 in., paperbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; $6.00 per copy.*

Replacing the 1958 publication, this compilation contains all the ASTM specifications for carbon and alloy-steel pipe and tubing. Covered are pipe used to convey liquids, vapors, and gases at normal and elevated temperatures; still tubes for refineries; heat exchanger and condenser tubes; and boiler and superheater tubes. Included are specifications for castings, forgings, weldings, and nuts and bolts used in pipe and related installations.

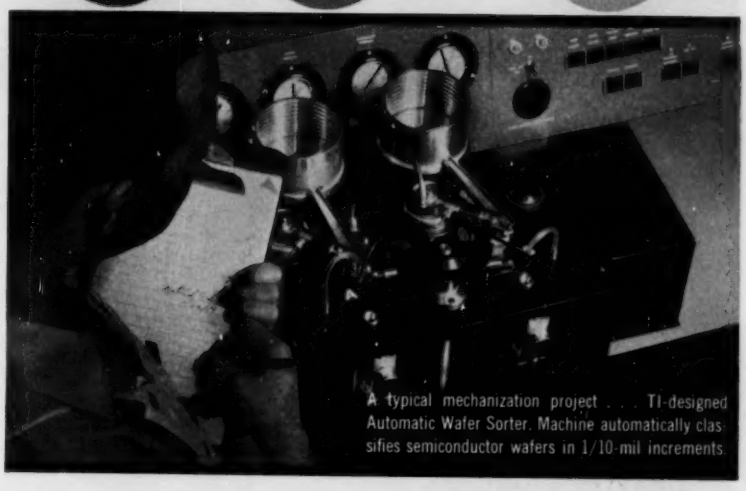
Association Publications

3-Year Interim Report of Corrosion Tests on Metallized Coatings. *7 pages, 8¼ by 11¼ in., paperbound, stapled; available from American Welding Society, Dept. T., 33 West 39th St., New York 18, N. Y.; $0.50 per copy.*

Results after three years of a 12-year evaluation program are presented. Over 4300 specimens of metallized coatings over base steel were exposed at eight different test sites. Zinc and aluminum coatings, with seal coatings, were tested in rural, industrial, salt-air, and salt-spray environments. Surface preparation, coatings, thickness measurements, and test sites are discussed. Atmospheric effects on test samples are illustrated.

Proceedings of the National Electronics Conference—1958—Vol. 14. *1074 pages, 6 by 9 in., clothbound; published by and available from National Electronics Conference Inc., 228 N. La Salle St., Chicago 1, Ill.; $7.50 per copy.*

These Proceedings contain all papers and speeches presented at the Conference in October, 1958. Included are transcripts of sessions on the International Geophysical Year and speeches by Gen. John



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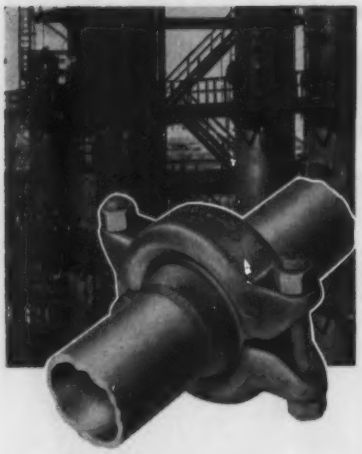

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Circle 525 on Page 19

Medaris, Donald B. Quarles, and Dr. Simon Ramo. Papers describe latest developments in transistors, network theory, microwaves, instrumentation, noise, engineering writing and speech, computers, television, industrial electronics, and engineering management.

Properties of Cast Iron at Elevated Temperatures, STP 248. *90 pages, 8¼ by 11 in., paperbound, stapled; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; $4.25 per copy.*

Properties of six commercial low-alloy gray irons and one unalloyed ferritic nodular iron were evaluated at 800 F and 1000 F—both as-cast and annealed. Tests included metallographic examination and tensile, creep-rupture, thermal shock, and growth tests.

Government Publications

OTS Technical Reports. *Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.*

PB 151445. Investigation of the Compressive, Bearing, and Shear Creep-Rupture Properties of Aircraft Structural Metals and Joints at Elevated Temperatures. By Luke A. Yerkovich, for WADC; 98 pages, 8¼ by 10¾ in., paperbound, stapled; $2.50 per copy.

Stresses under both short and long-time loading at high temperatures were examined for characteristics applicable to riveted joints. Bearing creep and rupture strength were studied for 2024-T3 aluminum alloy sheet at 300, 450, and 600F. Short-time high-temperature properties of 16 test alloys were determined. To correlate existing shear and bearing creep data with high-temperature joint behavior, three types of joints were tested using 2024-T3 aluminum and C-110M titanium alloy sheets.

PB 151566. Tensile Properties of Aircraft-Structural Metals at Various Rates of Loading after Rapid Heating. By Haywood E. Dedman, Edmund J. Wheelahan, and J. Robert Kattus, for WADC; 197 pages, 8¼ by 10¾ in., paperbound; $3.50 per copy.

Modulus of elasticity, per cent elongation, proportional limit, stress-strain curves, 0.2 per cent offset yield strength, and ultimate tensile strength were determined for Chro-Mow tool steel, Thermold-J tool steel, Peerless-56 tool steel, AM-350 precipitation-hardening stainless steel, and 6 Al-4V titanium alloy. Specimens were brought to temperature within 10 sec, held at temperature for periods ranging from 10 to 1800 sec, and loaded at strain rates from 0.00005 to 1.0 in. per in. per sec. The steels were tested at temperatures up to 1200 F, and the titanium alloy up to 1000F. Full stress-strain curves were also obtained for 17 other alloys which previously had been partially examined.

PB 151627. Air Research and Development Command Technical Symposium. 494 pages, 8¼ by 10¾ in., paperbound; $7.00 per copy.

Propulsion systems and materials for space vehicles were discussed at a symposium held July, 1958. Papers on structural materials dealt with aluminum, magnesium, beryllium, steels, super alloys, adhesives, graphites, plastics, and surface treatments. Special-purpose materials included elastomers, lubricants, glasses, shielding, and textiles.

Reports on electronic materials covered synthesis and application, energy-transforming materials, insulation and dielectrics, magnetic materials, and transistors. Other papers were presented on propulsion materials and materials research, application, and processes.

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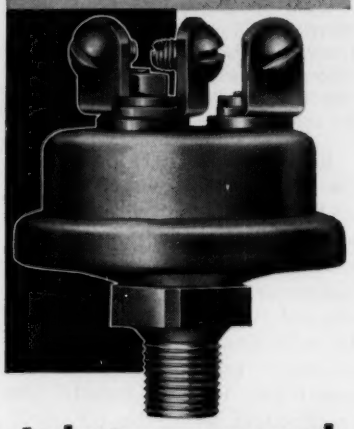

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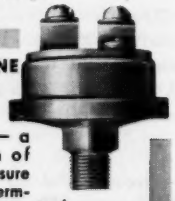

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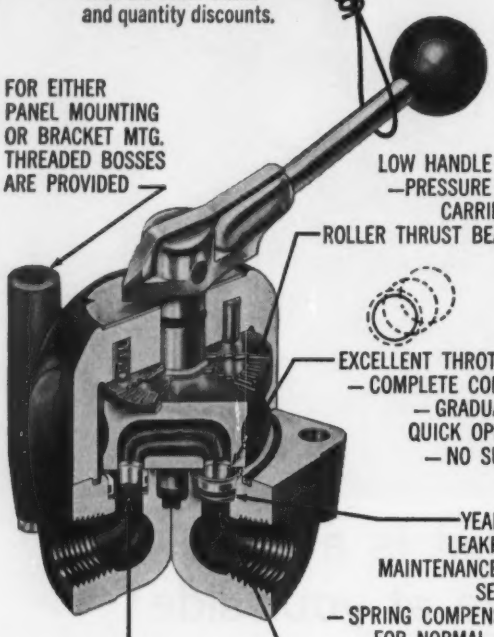
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Professional Viewpoints

. . . cyclic three-gear drives . . .

To the Editor:

May I be permitted to comment on "Cyclic Three-Gear Drives" in the March 19 issue of MACHINE DESIGN.

It is very regrettable that the authors apparently were not aware of the fact that the "three-gear drive," posing one of the most interesting problems in kinematics, is not merely one of the many mechanisms which convert uniform rotary motion into one with cyclically changing output velocity. It is not quite clear from the article what the authors mean by "optimum velocity," since they omit a definition of this term.

But the outstanding value of this mechanism is not the changing output velocity. Its main attraction lies in its application as an intermittent drive.

The mathematical and kinematic theory of this fascinating drive has been extensively investigated by J. S. Beggs in *Mechanism*, pp. 50-53, McGraw-Hill, 1955; by Prof. F. Freudenstein in "An Analytical Approach to the Design of Four-Link Mechanisms," *ASME Trans.*, Vol. 76, No. 3, April, 1954, pp. 483-488; and S. Rappaport, "Kinematics of the Three Gear Drive," *Product Engineering*, Jan. 1950, pp. 120-123. Graphical as well as mathematical ways to obtain the output velocities and accelerations are shown in these papers, in addition to establishing the formula for the "critical center distance," i.e., the center distance which must be used in order that the output velocity pass through zero.

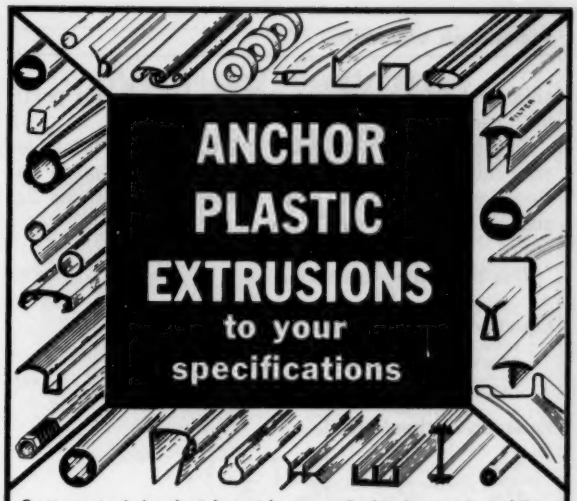
—SIGMUND RAPPAPORT
Ford Instrument Co.
Long Island City, N. Y.

To the Editor:

I must admit that the omission of making a point of the intermittency conditions and the lack of reference to Mr. Rappaport's article is most regrettable.

As to the merits of a mathematical analysis for the three-gear drive, the primary one is the accuracy with which the kinematics can be calculated. Moreover, for the case where the input and output gears have the same number of teeth, the mathematical expressions simplify to the point that the actual calculations would seem to be less time-consuming than the graphical methods.

By optimum drive conditions, the article refers to the case where the peak magnitudes of acceleration and deceleration are equal. This condition corresponds to the lowest peak magnitude of acceleration or deceleration for a given ratio of maximum to minimum output velocity. The reduction of acceleration or deceleration peaks to the lowest possible level is dynamically desir-



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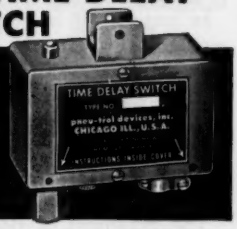

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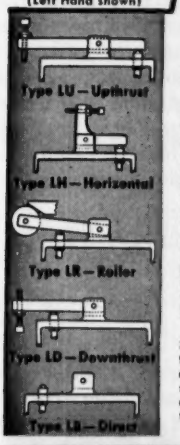

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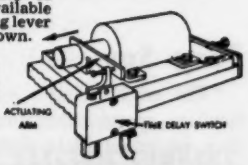

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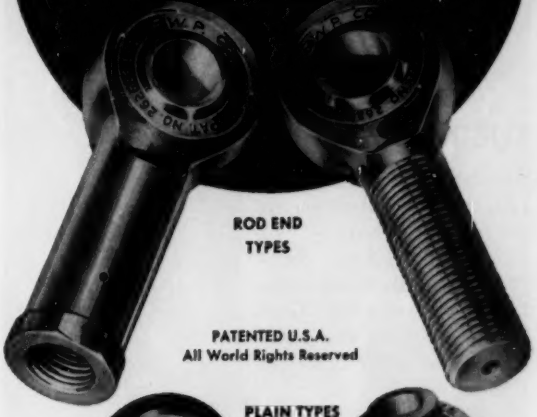

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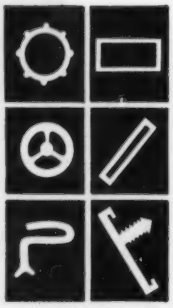

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able, and no attempt was made to belabor this point in the article.

In connection with this article, I must bring to your attention an omission which I have made in Equation 2 which followed through to Equations 2*a* and 2*b*. Equation 2 should read,

$$d\theta_{2c} = d\theta_{db}\left(\frac{R_1}{R_2}\right) - d\theta_{bc} \qquad (2)$$

Equation 2*a* should read,

$$\frac{d\theta_{2c}}{d\theta_{da}} = \frac{d\theta_{db}}{d\theta_{da}}\left(\frac{R_1}{R_2}\right) - \frac{d\theta_{bc}}{d\theta_{da}} \qquad (2a)$$

Equation 2*b* should read,

$$\frac{d\theta_{3a}}{d\theta_{da}} = -\frac{d\theta_{ca}}{d\theta_{da}} - \frac{d\theta_{db}}{d\theta_{da}}\left(\frac{R_1}{R_3}\right) + \frac{d\theta_{bc}}{d\theta_{da}}\left(\frac{R_2}{R_3}\right) \qquad (2b)$$

—JOSEPH KAPLAN
Fairchild Camera and Instrument Co.
Syosset, N. Y.

While confessions are in order, the symbol in the horizontal scales for Fig. 2 and 3 should be changed from $d\theta_{da}$ to θ.

—ED.

. . . the lost decade . . .

To the Editor:

In your April 16 editorial, "The Lost Decade," you question why, after 30 years, this group lags the field in salary. I do not disagree with your comments. But as a 1927 graduate, I doubt if the loss of several years of engineering experience is much of a factor now. Refresher courses, magazines like MACHINE DESIGN, and engineering societies, keep an engineer from being lost in the relatively rapid advances in current practice.

The graduates of 1925 to 1935 were hit by unemployment or drastic reduction in salary. Being relatively young, they viewed this turn of events as though their very survival were being threatened. Although they did survive, reactions ranged from feelings of persecution to thankfulness. And time will never wash out the effect of those years.

A recent comment, that we need fewer tranquilizers and more "give-a-damn" pills, may not apply to 1925-1935 classes.

—HENRY I. MORTON
Baltimore, Md.

They Say . . .

"The engineering scientist will require a wider curriculum, spend more time in school and, after graduation, be prepared to shift his field of endeavor several times. Gone is the time when a man could expect to train himself professionally in a specialized field and spend a lifetime there."—DR. ANDREW A. KUCHER, *vice president, engineering and research, Ford Motor Co.*

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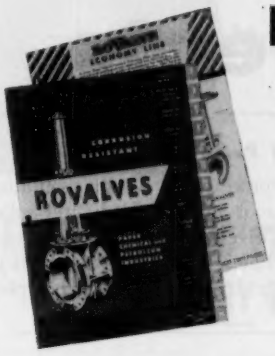

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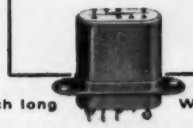

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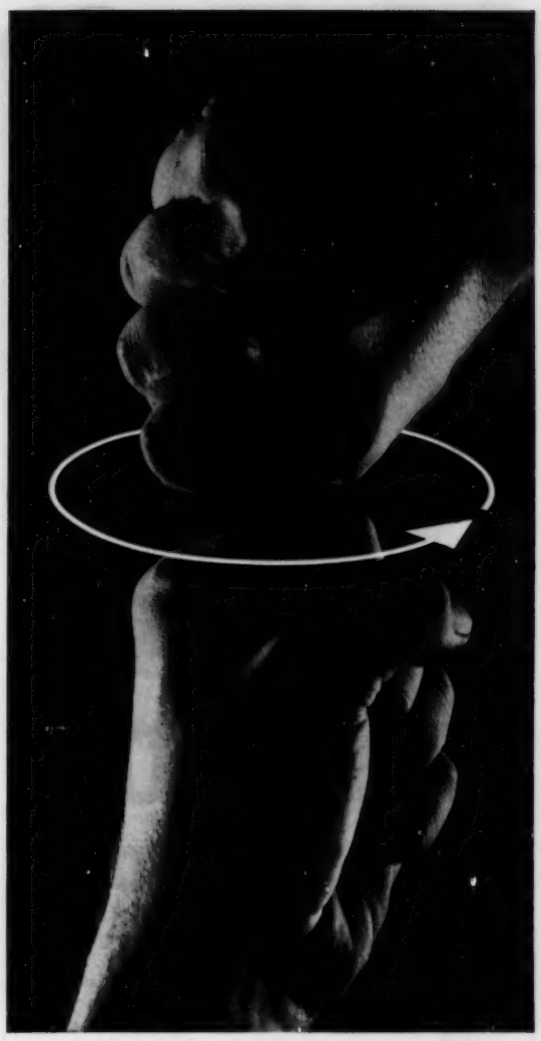

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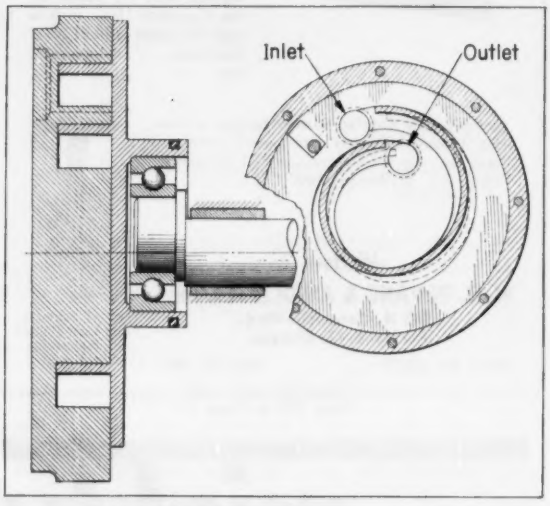
Patents

Continuous-Flow Scroll Pump

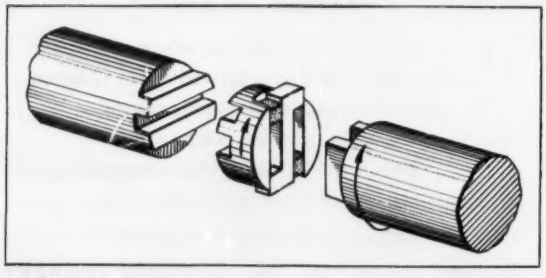
Within a stationary spiral channel, an oscillating partition provides continuous flow of fluids and solids at low driving torque. Driven by an eccentric on a power shaft, a plate oscillates in a plane perpendicular to the shaft axis. Integral with this plate, the spiral



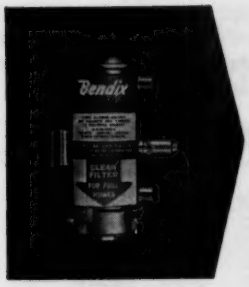
partition projects into a constant-width spiral channel in a fixed member. At all times, the partition contacts the walls of the channel at three points. The effect of oscillation is to move the contact points, essentially as in rolling surfaces, thereby dividing the channel into continuously rotating vacuum and pressure chambers. *Patent* 2,841,089 *assigned to Rand Development Corp., Cleveland, by John Lester Jones.*

Cushioned-Jaw Flexible Shaft Coupling

A flexible coupling assembly uses a short intermediate shaft grooved to receive a rigid Z-shaped member and



two resilient blocks. During acceleration, torque is transmitted only through the rigid Z which prevents relative displacement of driving and driven shafts in



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IN DURABILITY

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In every type of industrial application, the Bendix* Electric Fuel Pump has proved itself with outstanding performance under extremely adverse conditions. In tests conducted under U. S. military supervision, it has proved itself at temperatures ranging from 114° to −76° Fahrenheit. It's easy to install and service, has a built-in pressure release, pumps more gallons per hour and positively prevents vapor lock. It will outperform any other fuel pump anywhere near its price. Write for descriptive folder and specifications. *REG. U.S. PAT. OFF.

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ECLIPSE MACHINE DIVISION

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AVIATION CORPORATION

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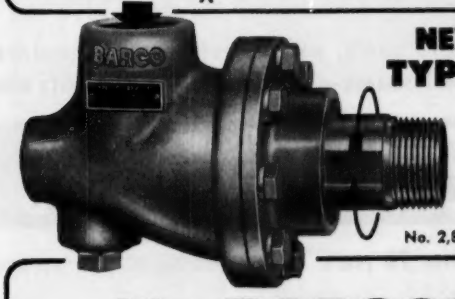
Need a Better rotary joint?



NEW TYPE C

Patent No. 2,836,439

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For countless applications, Barco's new Type C Rotary Joint will give you the best operating records you've ever had—*and for LESS COST!*

"CRACK-FREE" CHROME PLATED SLEEVE—A standard Barco feature. Minimizes corrosion, friction, wear. Stainless steel spring also standard.

RESISTS SEAL RING BREAKAGE—The spherical seal ring is under compression, not *tension*, loading. Self-adjusting for wear. Seal withstands shock loads and alternating hot and cold service.

WIDE SPACED BEARINGS—Two, instead of one . . . increased bearing area. No lubrication required. Lowest friction.

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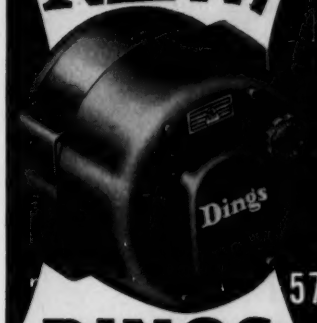

wear adjustment requirements eliminated on Magnetic Disc Brakes rated 125 to 575 lbs. ft. torque

DINGS SELF-ADJUSTING BRAKES

Think of the maintenance money you'll save! *No* adjustment for wear is required on these new Dings "90M Series" magnetic Disc Brakes, even in the higher torque ratings. They *automatically* adjust for wear, practically eliminating maintenance until disc replacement is necessary.

High thermal capacity is another welcome Dings Brake feature. It means that Dings can give you brakes for combination brake-motors for high inertia loads or high frequency starts and stops.

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Dings new Self-Adjusting Brakes are designed for "C" flange motor mounting on frames 324UC through 505C, or for foot mounting.

Dings Complete Line Solves Your Brake Problems

STANDARD *Direct-Acting* MAGNETIC DISC BRAKES

18 Models of Dings Standard Magnetic Brakes, with a torque range of 1½ to 175 lbs. ft., meet every requirement for smooth stops and dependable holding, with low maintenance. Available for "Thru-Shaft" applications.

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Dings Hazardous-Location features are tested and approved by Underwriters Laboratories. The "707" Series models are for Class I, Group D. The "709" Series are for Class I, Groups C and D, and Class II, Groups E, F, G.

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This low-inertia, positive engagement clutch coupling utilizes serrated teeth for transmitting high torques without slippage. Meets a wide range of applications, with ratings from 1200 through 32,000 lb. ft. torque. DB-258½

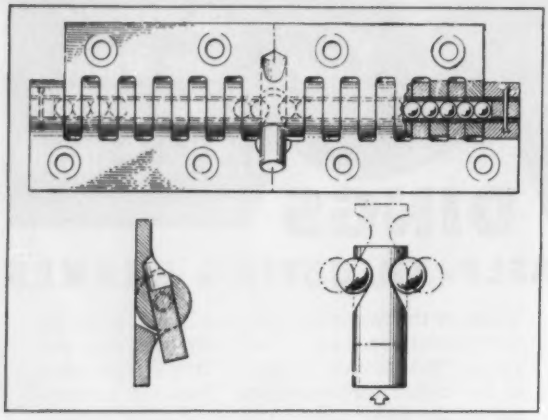
Take advantage of Dings complete engineering service for your brake or clutch problems. Write or phone today.

DINGS BRAKES, Inc.
A Subsidiary of Dings Magnetic Separator Co.
4714 West Electric Ave., Milwaukee 46, Wis.

Circle 539 on Page 19

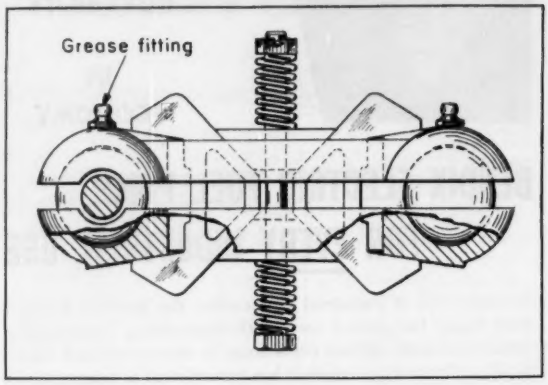
the driving direction. During deceleration, overrunning torque is cushioned by the blocks. *Patent 2,892,328 assigned to Burroughs Corp., Detroit, by William R. Templeton.*

Quick-Release Hinge



In a hinge assembly, the conventional pin is replaced by balls which enable the hinge to flex easily and to disconnect quickly. In the joined condition, the balls are spaced so that each spans adjacent surfaces of the two hinge halves. When the hinge is loaded, the balls move slightly, but not out of engagement, to take up assembly tolerances. This same action aids disconnection, when a central wedge-pin, driven on its own axis, displaces all balls a distance of one radius. *Patent 2,892,210 assigned to General Dynamics Corp., San Diego, Calif., by Samuel Merkowitz.*

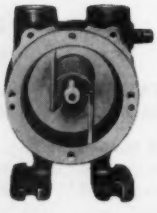
Wear-Compensating Link Assembly



At opposite ends of a link assembly, spheres carried in pairs of mating jaws comprise the pivots of the link. The jaws grip the spheres with wedging force transmitted by plane surfaces on the exteriors of the jaws and on adjacent members in the assembly. These surfaces are loaded by two springs at the center of the link. Action of the springs compensates for wear of the spheres and their cups. *Patent 2,891,418 assigned to J. I. Case Co., Racine, Wis., by Carlisle F. Smith.*

Higher Vacuum . . . Suction . . . Pressure with Smaller Pumps!

Metal Vanes take up their own wear



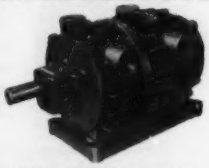
4-VANE TYPE. Vacuums to 20" Hg.; pressures to 15 lbs.; displacement to 162 c.f.m. Vanes hinged to pistons maintain continuous sealed contact with cylinder walls by centrifugal force. Small pistons, large air chambers, greater capacity.

2-VANE TYPE. Vacuums to 29.9" Hg.; pressures to 20 lbs.; displacement from 2.4 to 105 c.f.m. Automatic Vane adjusting lever forces wear-resistant steel blades to cylinder walls, preventing sticking or binding, maintaining positive vacuum or pressure.

COMPACT INTEGRAL PUMP and MOTOR

27" Hg. Vacuum
20 psig. Pressure

Two models, 3.6 c.f.m. and 7.2 c.f.m. Uses Leiman 2-vane pump. Fan-cooled for continuous operation. Automatic oiler, over load protection, ball bearings. Inlet filter and outlet separator for oil-free air.



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LEIMAN Rotary Positive **AIR PUMPS**

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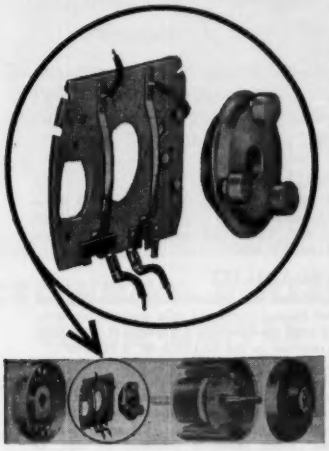
To Cut Out Starting Windings



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...And another intriguing advantage of Syncro Snap Switches is that they are available at less cost than you could make them yourself, even if they weren't covered by patents and patents pending (No. 2,616,682).

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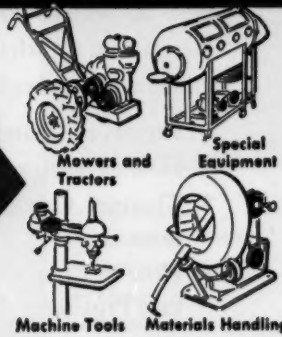
VARIABLE PITCH SHEAVES
Control Speeds on Variety of Machines



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- FOUR FLEXIBLE SEALING SURFACES
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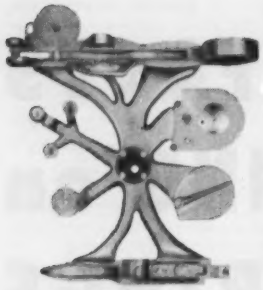

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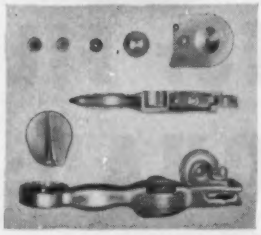
One Shot . . .
8 PARTS !



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Each high-speed casting shot supplies practically all the major parts for this labeler. Subsequent trimming by Dollin, delivers these zinc parts with close accuracies and a smooth hardware finish, ready for finishing and assembly —at low piece cost.

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GLIDER-ABILITY!!

GLIDER® Vertical Blue Print Files

Up to 1800-print capacity

GLIDERS merge functional design with the strength of steel for faster filing of more plans in less space. Within the straight line styling of gleaming gray GLIDER frames, there are other "profit-abilities"

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GLIDER plan holders, 20" to 48" long, hold up to 100 prints each. Spaced thumbnuts provide direct clamp control. Single and multiple sheets or sets are held equally firm.

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"T"-tops of each plan holder "glide" into and out of, rigid, steel channel-tracks. As print quantity increases, users add extra plan holders. A capacity of 1800 prints may be retained in the GLIDER 48" x 36" x 60".

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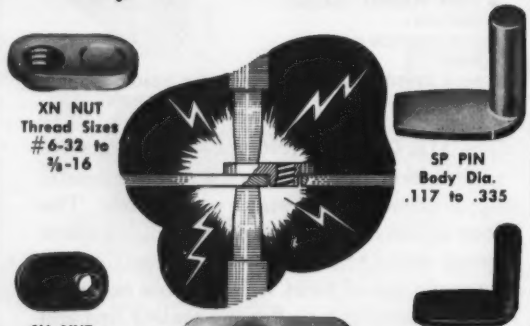

If you do spotwelding you can attach OHIO Spotweld Fasteners at the same time for faster, trouble-free assembly.

Samples and information available upon request.

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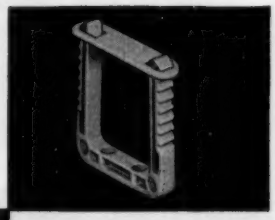

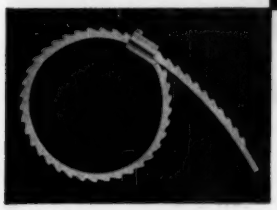

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Sensitive H9 J10

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UNITED ELECTRIC's Type H9 and Type J10 controls are highly sensitive precision built pressure and vacuum controls designed for applications where close on-off differentials and constant repeatability are required. Type J10, being uncalibrated, is smaller and less expensive than Type H9 which is calibrated and has a knob & dial adjustment.

Specs:	
Various Ranges	H9-J10 — between 30" Hg. Vac. and 15 P.S.I.
Switch Differentials	H9 — ½ to 1 ±1/10" W.C. depending upon model. J10 — ¾ to 1 ±3/10" W.C. depending upon model.
Switch Ratings	Standardly 3 amps 115/230 A.C.
Switch Types	N.O., N.C., or Double throw, no neutral position.
Electrical Connections	Made to screw terminals on switches through clearance hole in enclosure.
Pressure Connections	One ¼" NPT pressure connection.
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No loss of holding power — you can use rugged Dubo Lockwashers time and again.

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NON METALLIC FASTENINGS OF ALL TYPES
Patents applied for.

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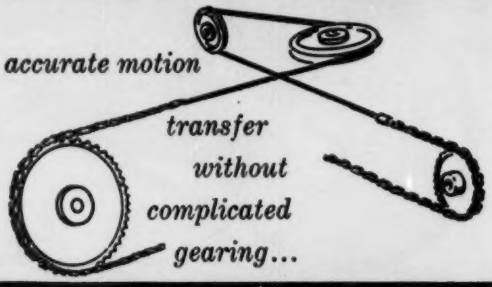

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Provide precise, positive motion transfer through several planes simultaneously with no cable slippage...no complicated gearing. Unlimited center-to-center selection for miniature and sub-miniature assemblies in servo systems, gyro systems, special cameras, electronic equipment, and small precision instruments. Less weight, cost, maintenance —wider tolerances. Designed to operate around minimum 7-tooth sprocket with root diameter of .250 inches. Chain pitch .1475 inches; Weight .45 oz. per lineal ft. Material: stainless steel, or other materials, including non-magnetic beryllium copper.

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Sierra ENGINEERING CO.

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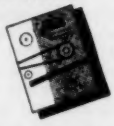

Contains useful application data, specifications, tables on chain pitch and sprocket sizes, suggestions for calculating center-to-center distance. *Write for yours today.*

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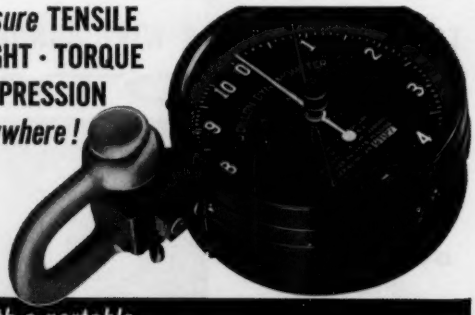

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- 13 CAPACITIES: 0-500, 0-1000, 0-2500, 0-3500, 0-5000, 0-10M, 0-15M, 0-20M, 0-30M, 0-40M, 0-50M and 0-100M pounds.
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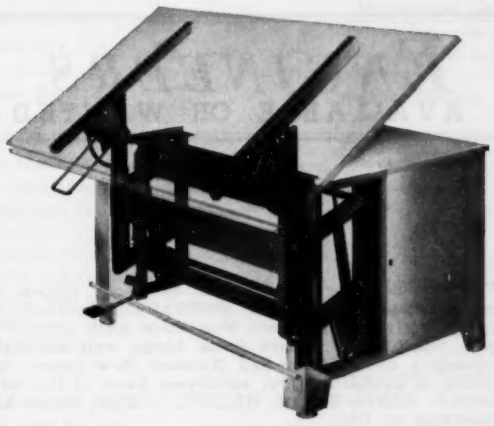

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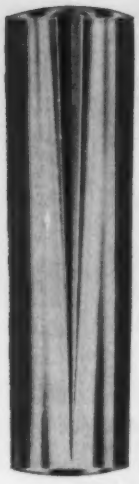

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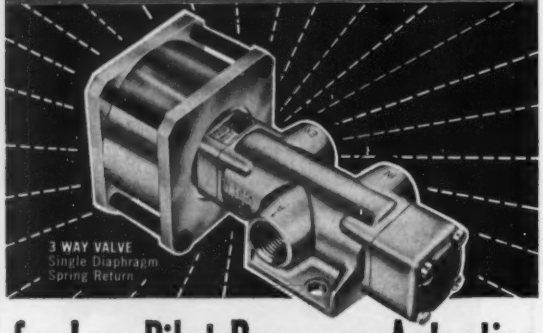

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BPA NBP

backtalk——

—The Living End

Every issue, in some way, we try to get better and better. We create new departments, modernize layouts—do all kinds of things to make MACHINE DESIGN a better magazine for you. And now we are even providing this page of light reading as a sort of dessert for more substantial fare which precedes it. Named for its location and—with just a hint of *double entendre*—for its content, Backtalk will contain behind-the-scenes glimpses of MACHINE DESIGN's contents and the people who put it together. There will also be miscellaneous items of interest to design engineers. Unlike the rest of the magazine, this page probably won't be a bit helpful to you in your work; like the other pages, though, it's yours, and we will welcome reactions—perhaps in the form of printable comments—to it.

—Editor and Friend

In case you've been wondering what the "SBME" emblem displayed on our editorial masthead (Page 4) stands for, it means that several of our editors belong to the Society of Business Magazine Editors. This group, which is the editors' professional society, met in Washington last June and paid a visit to President Eisenhower at the White House. This picture, snapped by SBME member Don Foxvog, shows the President addressing the assembled editors in the conference room outside his office. Withdrawn into a respectful fuzziness at the right of the photo is MACHINE DESIGN's editor who, as president of the society this year, introduced the group to Ike.

—Applied Mathematics

Beating a rap for speeding by means of *what* you know, rather than *who* you know is a singular feat. This switcheroo was pulled off by a Canadian chap who has a thorough —and useful—knowledge of mathematics. A radar unit clocked him at 38 mph; he claimed this was inaccurate, since the radar is set up to gage speed of 18-ft long cars and his sports car is only 13 ft long. Thus the error was 5.92 mph, and his actual speed was a respectable 32.08 mph. Our hero spent eight hours working out a formula to prove his claim. He offered to explain it to the judge, but that worthy official declined—and dismissed the case.

—Call to Color

Unlike the red lining of the bullfighter's cape—which appeals to spectators but has no effect on the bull, who charges only movement —color in consumer items is an effective weapon in the designer's contest for product acceptance. His adversary, John Q., is unpredictable. He thinks he would like to have his letters typed on a bright-colored typewriter, but ends up buying a somber black or gray one; he goes car-shopping, sure that he will drive home in a conservative black model, then loses his heart to a sporty two-tone job. Faber Birren, author of this issue's "spectacular," doesn't presume to explain why people react to color as they do; instead he suggests ways to design color into products. In the event you missed Mr. Birren's article, or if you are a reader who goes through magazines from back to front—we refer you to Page 100.

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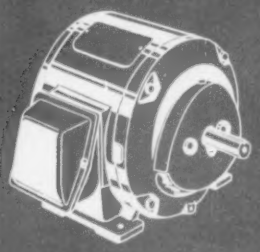

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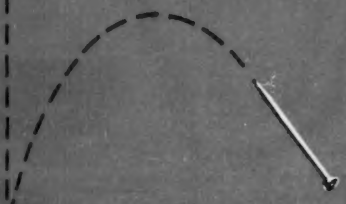

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MASTER REEVES

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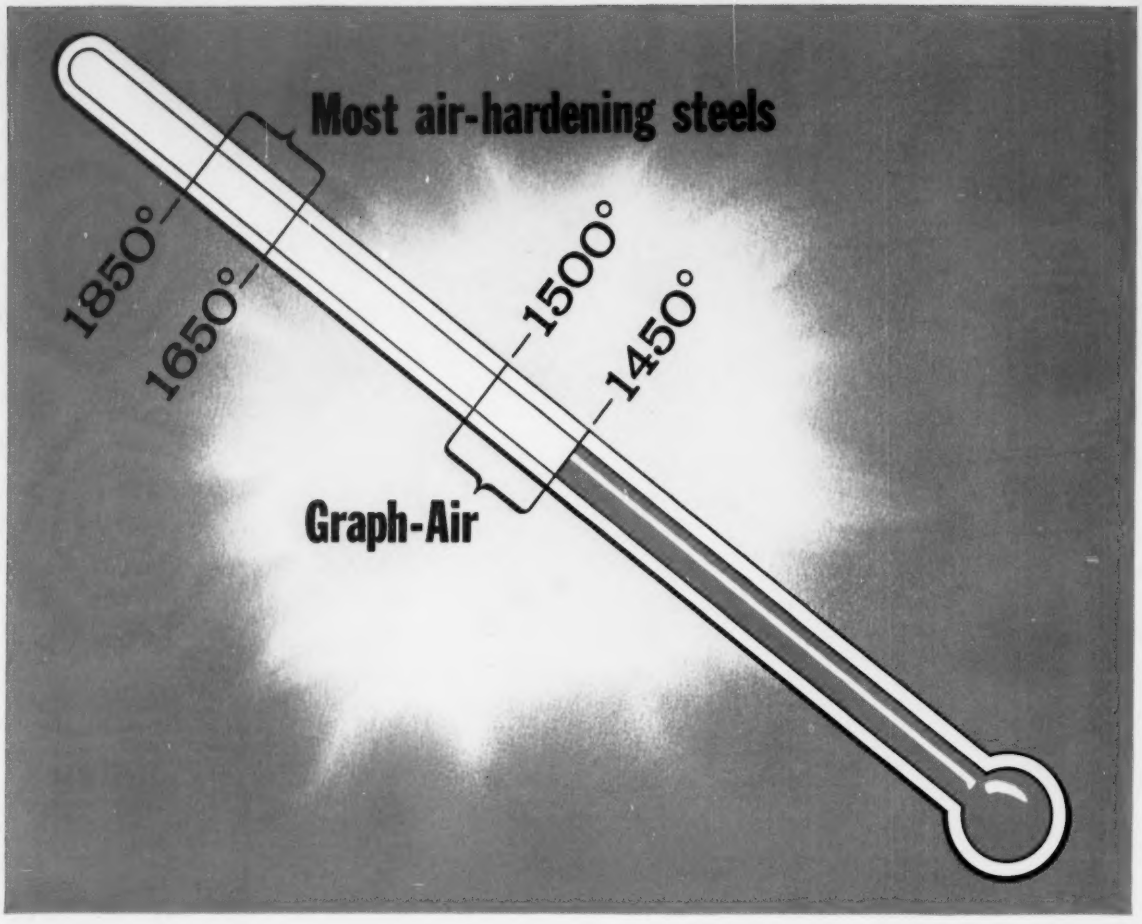

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